SCHOOL SCIENCE

AND

MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal
for all
SCIENCE AND
MATHEMATICS
TEACHERS

CONTENTS:

SCHOOL SCIENCE AND MATHEMATICS

WHAT APRIL BRINGS.

In this issue we present an exceptionally good article for all teachers of science to ponder over. It is written by Dr. Joseph M. Jameson, Vice President of Girard College, Philadelphia, Pa. Several years ago Professor Jameson contributed an excellent series of articles and it is with unusual pleasure that his article on "Artificial Crutches in Science Teaching" is published this month. His experience as teacher, supervisor and administrator has given him a view point that makes his observations worthy of attention.

Are you interested in number tricks, big numbers, number poetry and all kinds of sidelights on number relations? If so, we have a real treat for you this month on page 395. Professor Thomas E. Mason of Purdue University has provided the feast. Professor Mason is another of the famous Hoosier teachers who knows his mathematics and also knows how to make it interesting.

This issue has many more good things but we dare not take more space to tell you about them.

NEXT MONTH.

Dr. N. Henry Black of Harvard University now on leave of absence studying at Cambridge England will describe a series of very interesting experiments telling how to measure the performance of an automobile. Here is an opportunity to show your boys how physical laws are made use of in an engineering problem and will give the boys a method of testing their Leaping Lenas.

Mr. J. M. Jacobs, Head of the Mathematics Department, Glenville High School, Cleveland, Ohio has learned the art of getting every student to work up to the limit of his ability. He will tell us how to do it.

The May issue will contain a strong list of articles placing emphasis on methods of teaching, aims, objectives and tests.

FROM AROUND THE GLOBE.

During the month of February the editor received letters from Leipzig, Germany; Cambridge, England; Paris, France; Funchal, Madeira; Groningen, Netherlands; Toronto, Canada; Shanghai, China; Mexico City and Honolulu. That this is just the ordinary month's grist has not been verified, but it is at least typical. We just kept a record of February so this item could be written. We thought you would be interested. These pieces of mail carried articles for publication, requests for information on science topics, requests for book lists, and announcements of new books.

SPIRIT OF THE CLASSROOM.
By W. Whitney.

In visiting classrooms, whether they be used for science or academic work, one cannot but be struck by the difference in the atmosphere of the rooms. Without being told the visitor in one type of rooms knows what is being taught there. The decorations of the room—it may be pictures on the wall, various objects pertinent to the subject taught, numberless little things—plainly tell the story. The room is permeated with it. In other rooms an investigation is needed to reveal the work done there. The room is bare and barn-like. Every one has come across such rooms.

Teachers of botany have a peculiar advantage in that the work with plants lends itself to such uses. Window plants, improvised vivaria, balanced aquaria with their water life, winter blooming bulbs developing from bulb to flower and seed, the opening of buds, germinating seeds, are only a few of the many possibilities of the work with plants easily realized in practice. They are all telling the

story of the living processes of plants and cannot but awaken interest and enthusiasm in the pupils who watch such a panorama from week to week. The teacher here has a privilege and a duty in this process of inspiring the students with love for the subject. It must also be most inspiring to the teacher to watch the effect of this spirit in his pupils.

A RESISTANCE EXPERIMENT FOR THE HIGH SCHOOL CLASS.

By GEO. P. UNSELD, *Salt Lake City*.

Most teachers of high school physics have, at one time or another, designed experiments in measuring resistance by use of the ammeter and the voltmeter. After trying a large number of different combinations, using potentials up to 110 volts and a large variety of coils, the writer has found the following method to be far the most satisfactory.

For the source of current he uses an Edison storage battery of five cells, although a lead battery should also give good results. The unique part of the experiment consists of the coils of which the resistance is to be measured. These are long spirals of bare steel telephone wire. Because of the low potentials used, in many cases that of but one cell of the battery, insulation is not necessary and the strength of the wire keeps the turns separated.

To form the coils one needs a vise, a piece of tubing, and a metal rod that can be inserted into the tubing. One end of the rod is bent into a handle and the wire is wrapped around it as one wraps a rope around a windlass. Six feet of coil can be wrapped with a two-foot rod by removing one layer from the rod and wrapping this about the handle while a second layer is wound. A third layer can be then wrapped in a similar manner.

These coils have a resistance of from one-half to two ohms and hence give convenient currents when used with one or more cells of the battery. There is no danger from electric shock and no fuses to "blow."

It has been the practice of the writer to have his pupils measure the resistance of each of three coils separately, then of the three in parallel and then in series. These last may be checked against the values as found by calculation from the resistances of the separate coils. One satisfactory method of connecting the coils is by holding the ends together with wrappings of bare copper wire.

In using the formula for finding the value of resistances in parallel it is much simpler to reduce the fractions to decimals and add, than it is to use the method involving a common denominator. This is readily seen from the following example.

$r_1 = .682$ ohm, $r_2 = .743$ ohm, $r_3 = 1.237$ ohms.

$$1/R = 1/.682 + 1/.743 + 1/1.237$$
$$1/R = 1.466 + 1.346 + .8084$$
$$1/R = 3.620$$
$$1 = 3.620R$$
$$R = .267 \text{ ohm.}$$

WHAT WISE MEN STUDY IN SCIENCE.
BY HANOR A. WEBB,
George Peabody College for Teachers, Nashville, Tenn.

More than three times as many Ph. D. diplomas in chemistry were granted last year by American universities as in the nearest competing field of science for graduate honors—zoölogy.   In twenty-two different avenues of science these awards were given.   The list, carefully compiled by two efficient workers[1], is an evidence of what learned men and women chose to study at this time and in this nation.

A tabular list of figures would not interest young science students. This information, however, is in my judgment of high recruiting value —useful propaganda, if you will permit the word.   Science teachers naturally hope that many of their students will continue in the pursuit and advancement of scientific knowledge.   Science is so diversified, however, that it is not enough to give the advice, "Be a scientist"; for science that becomes an earnest life-work is almost sure to be specialized.

·Sometime, somewhere, each science student is sure to ask, "What do wise men study in science?"[2]   These data give an answer in statistical terms—and here is how I would endeavor to translate the information for the young folks.   "Bread rather than stones"—you remember the reference.

Have you heard the word *research?*   "Search" in Latin means "to go about in circles; "re" means "again."   Research, therefore, is hunting all around—again and again. Hunting for what?

Of course you understand the word *science;* it is Latin for "to know."   *Scientific research* is therefore a patient hunting for knowledge.

Are there many kinds of knowledge?   Wise men have argued about this.   Some insist that all knowledge is so closely related that there is one great principle of Truth. This may have many parts—just as a city has many homes. It has been convenient for scientists to classify knowledge into many smaller divisions, however; using again the illustration of the big city, we may call them Avenues of Truth. While on every "street" in the "City of Science" some people live, yet certain sections are more crowded than others.

Let us learn which are the more popular streets in the City of Science from recent reports of a kind of "scientific

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[1]"Doctorates Conferred in the Sciences by American Universities, 1929-1930," by Clarence J. West and Callie Hull, *Science* ns 72:357, October 10, 1930. Data slightly corrected later.

[2]The number of doctorates in Education is probably about one hundred for the same period, but this field of science was not included in the data.

census" that a most helpful agency, the National Research Council of Washington, has carried on. Some day you will doubtless try to select for yourself the particular things you wish to do in life, and it is most likely that you will consider turning the corner into one or the other of these scientific avenues. At the outset let me urge you not merely to turn with the crowd; there are perhaps certain streets with fewer pople that you would find most pleasant for your abode.

The information that we have from the Council tells of the number of persons who moved in on the different streets during last year (1930). Each has built a home upon that street by several years of earnest labor. He has definitely chosen one particular street, we know, because some great university or college of the United States has pronounced him to be better fitted for that street than any ordinary man could be, and has awarded him a diploma that entitles him to be called "Doctor So-and-so." Remember, the figures I give you are for the new-comers of 1930; there are others already living there who moved in during former years.

The Avenues of Science City.

Chemistry Avenue. Three hundred and seventeen new homes were built on this street last year. This is the largest number to receive their diplomas for any single avenue of science. Chemists study all kinds of materials, analyze them, learn to make new products from them. Dyes, rayon, steel, soaps, drugs, are but a few of the chemist's inventions. For several years this has been the most popular avenue of all, and it will possibly continue to be so for a considerable time.

Zoölogy Avenue. One hundred and two new homes are to be seen on this street. This is the second greatest number of diplomas. Zoölogists study the lives and habits of animals; they experiment on how animals inherit their colors, habits, and dispositions; they learn how different foods affect animals. Presumably the things that zoölogists learn about animals should be valuable principles concerning human bodies.

Psychology Avenue. Ninety-seven houses of 1930 construction are on this avenue. Psychologists study the

human mind; they discover how we learn, and therefore should be able to tell teachers how to teach, editors how to write, etc.   They also experiment with those unfortunates whose minds are seriously ill, and learn of the treatments that should be given to them.

Physics Avenue.   Ninety-one new families came this past year.   Physicists study a great variety of matters concerning energy and work, sound, heat, light, electricity.   Some of the most marvelous inventions of recent times such as the radio, the airplane, the automobile—are due to their practical knowledge.   We have heard, however, that high school students often fear to enter this street to see whether there is vacant land upon which they might build; they have heard that the roadway was very rough, and hard to pass through.   Those who dwell upon this avenue say that this idea is not true at all!

Botany Avenue.   Eighty-one homes were built here last year.   Botanists study the laws of Nature by which plants grow.   Among their most interesting discoveries are ways by which new plants may be formed—plants of which Nature never thought!

Mathematics Avenue.   Seventy-five new homes were erected upon this avenue in 1930.   We are sure that they are perfectly arranged—for is not mathematics the "perfect sciene?"   You may have heard it said, "All the mathematics has now been discovered."   This cannot be true; no one knows how long this street may be.   Dr. Albert Einstein, the famous German mathematician, seems to have started mathematics all over again!   Mathematicians deal with figures, and what marvelous things they do with them!   All scientists pay visits to Mathematics Avenue from time to time to obtain things—groceries of a sort—that they need in their own homes on other avenues.

Geology Avenue.   Sixty-three new families moved in during 1930.   Geologists study the crust of our planet Earth, its composition, and its movements.   They learn about minerals, and how to get them.   They often visit friends on Chemistry Avenue for advice.

Engineering Avenue.   Forty-nine new homes were constructed on this avenue last year.   Engineers are wanderers that have finally settled down to work.   They have all

boarded for a time on Physics Avenue, lived even longer on Mathematics Avenue, and possibly a short time on Chemistry Avenue. They are more interested in practical truths than in deep, difficult ones; they prefer to set off fireworks rather than to study the sparkle of a diamond. This is a bright, lively street, with something always going on—but some folks would become nervous living upon it.

Physiology Avenue. Forty-six families moved in during the past twelve months. Physiologists study the workings of the human body; they learn the laws of food, of health, of long life. This is a quiet avenue, filled with patient people.

Pathology Avenue. Thirty-one new homes were built upon this street in 1930. Pathologists are kinds of doctors who make special study of the causes of pain, and the ways in which diseases affect the human body. They know, for example, the causes of toothache, and have discovered how to ease it. Their experiments should aid all physicians everywhere to keep us more comfortable.

Agriculture Avenue. Twenty-nine homes were built here in the year just past. This is a muddy street—but who cares, for on it grow the finest gardens, and in its yards the most interesting pets are to be found! Agriculture—humanity's oldest trade—is now a science. The discoveries recently made should cause farming to be more pleasant and profitable in countless ways. Folks who build upon this street may expect hard work, but they need never go hungry!

Bacteriology Avenue. Twenty-seven new homes were built in 1930. Bacteriologists are humanity's spies in the greatest of all wars—that of mankind against the germs. They capture the enemy's soldiers, and from them gain priceless information as to how the Microbe Army is moving, and what kind of ammunition is most effective against it. In ancient days the Germs often captured an entire country, and killed one-third or more of the people dwelling there! Ask your history teacher about the great plagues of the Middle Ages! The battle has not yet been won by Humanity.

Geography Avenue. There are many things about Mother Earth's skin and covering that are yet to be learned. Sev-

enteen new homes were built on this street in 1930; in each
of them dwells a geographer who has thoroughly investi-
gated some wrinkle on Mother Earth's face.

Anatomy Avenue.   Twelve new homes were built here
last year.   Anatomists study in greatest detail the bones,
muscles, nerves, and other tissues of the human body. Truly,
"we are fearfully and wonderfully made," as the psalmist
David sang centuries ago (Psalms 139:14).   It is well that
the form of even the tiniest cell in the human body becomes
known.

Public Health Avenue. Eight new families took up their
residence upon this avenue last year. This is a new street;
the first home upon it was built in 1926.   This should be
the cleanist, most attractive street in the City of Science—
and the healthiest.   Scientists must find ways to end the
human discomforts and dangers due to crowding; they must
keep all people as well as possible.   Thoroughly trained
people should move upon this street more rapidly in the
future.   They are needed.

Anthropology Avenue.   Six homes were built here in
1930.   The anthropologist has usually lived for a time on
Psychology Avenue, and probably on Zoology Avenue as
well.   He is interested in people, particularly the backward,
semi-average or actually primitive savages.   He measures
their bodies, studies their homes, their habits, and their
speech, and tries to account for their superstitions or be-
liefs of magic.   Perhaps the anthropologists will help re-
move the superstitions that we hold ourselves in the United
States!

Paleontology Avenue.   Six new families moved in last
year.   Nature is an historian; she wrote her book in the
rocks of the Earth's surface, and only paleontologists know
how to read her pages.   The history of this ball upon which
we live is perhaps more important than the history of the
mites—called men—that run about on its surface.   Who
knows!

Astronomy Avenue.   Four new homes were built upon
this avenue last year.   Astronomers study the stars, the
comets, the sun, moon, and planets, and all the bodies of
the heavens.   All astronomers have surely lived for a time
on Mathematics Avenue, and spent some months on Physics

Avenue. Many of them visit Chemistry Avenue frequently. Astronomy Avenue is wide, clean, and marvelously lighted; it is strange that more persons do not move upon it.

Surgery and Medicine Avenue. Four new homes were built here in 1930. It is hard to describe these scientists; they are physicians, yet they have studied some particular aspect of medicine or of surgery to its limit. This street is very close indeed to Physiology, Pathology, and Anatomy Avenues.

Metallurgy Avenue. Four new families selected this location for their residence last year. Metallurgists are glorified blacksmiths; they lived for a time on Chemistry Avenue, but decided to study particularly the treasure obtained from Nature's hoard. Metallurgists are discovering new uses for metals, and cheaper ways of producing and purifying them. Nature does not give man even his spoons ready made; he must work for his tools. Metallurgists help in making tools and machinery better and stronger. Most metallurgists have particular friends on Geology Avenue.

Minerology Avenue. Three new homes were erected on this avenue last year. Minerologists are glorified miners; they are partners of the metallurgists, and the two avenues lie side by side. Minerologists aid in finding the stores of useful ores in Mother Earth's cubboard; metallurgists obtain the pure metals from these rough ores, and put them on the market.

Archeology Avenue. Two new homes were built here in 1930. Archeologists are interested in the families of long, long ago. They wish to discover how men, women, boys, girls, and even the pets lived in the days of which Ancient History tells—or even before that. Often they must dig deep into the earth that has drifted or washed over the lost cities of past centuries. They find the relics of utensils, clothing, even toys; from these they try to imagine the daily duties and pleasures of those who lived and loved and learned so long ago. Archeologists may not be absolutely necessary scientists, but they are indeed interesting!

Meteorology Avenue. No one built a home on this avenue last year, but two were constructed in 1929, and two

others away back in 1922. Meteorologists study the science of the weather. Why, we wonder, are there so few of them? Perhaps it is because when they think they have made a great discovery, fickle Weather immediately does something against all the rules. Perhaps it is because scientists realize that although they may learn much about the weather, there is nothing they can do about it. Chemists, physicists, engineers, and many other scientists can control Nature; meteorologists can only predict, or foretell, her actions, and then be right only part of the time. Discouraging, isn't it? Meteorologists, however, are scientists brave and true.

Have the Avenues of Knowledge in the City of Science interested you? You must do something worth while in life! Why not consider the life of a scientist, and try early to choose a pleasant street upon which to build your home?

NEW U. S. FILMS SHOW WAYS IN WHICH FORESTS SERVE MAN.

Forests serve mankind in many ways, if man does his part. This is the theme of two new 1-reel motion pictures, sponsored by the Forest Service and made and distributed by the Office of Motion Pictures, Extension Service, U. S. Department of Agriculture.

"How Forests Serve" shows some of the ways in which protected forests serve by providing work in the woods, in mills, at factories, and in building. Most of the forest scenes are from the mountains of western North Carolina. Here are still to be found stands of chestnut, though the blight has begun to take its toll. The film shows ways in which the chestnut may be salvaged—the dead trees for acid wood, the bark for tanning extracts, and green, straight chestnuts for telephone poles. Another interesting film sequence shows the process through which the wood goes when it reaches a veneer factory. The closing scenes emphasize the fact that, in addition to practical values, forests have scenic and recreational values

"Unburned Woodlands," another 1-reel film, points out that unburned woodlands are homes for birds, game and other wild life; conservers of water; and places of recreation. Burned woodlands benefit no one. The advantages of unburned woodlands are contrasted with the disadvantages of burned woodlands in a series of scenes taken in southern forests and in fire-ravaged districts.

Copies of these films may be borrowed, without charge, other than the cost of transportation, by applying for bookings to the Office of Motion Pictures, U. S. Department of Agriculture, Washington, D. C. Copies made from the department negatives may be purchased at cost of printing by schools, colleges, State forestry departments and others interested.

So popular are the department's films, especially on forestry, that interested organizations have bought and are distributing as many copies as are being distributed by the department itself.

INTEGERS AND RELATED PROBLEMS.

By Thos. E. Mason,

Purdue University, Lafayette, Ind.

Most people do not think of Mathematics as an experimental science as they do, for example, of Physics. Yet most discoveries in Mathematics are made by experimental methods. A mathematical worker does not have to set up an elaborate laboratory equipment. A pencil and a few sheets of paper are usually sufficient. From his contact with problems or his reading of the work of others he gets ideas or "hunches" and tries them out. After experimenting a while he gets an idea of the underlying law and then sets about a rigorous proof. But he cannot prove anything until there is something to prove and that something to prove is usually arrived at in an experimental way. We are likely not to recognize mathematical research as experimental because the mathematician, having discovered something intuitionally or experimentally, puts his proof in logical form. We see the logical form and do not guess at the experimental development because we have never, for the most part, done any work in Mathematics except to study what someone else has already prepared.

About a hundred years ago certain men changed the axiom concerning parallel lines in our geometry, as we knew it in the high school, and developed the so-called non-Euclidean geometries. In these geometries experiment and intuition are no safe guides and the results are developed from the postulates. This postulational method has been used to a considerable extent, but while a century old, it is comparatively new in the growth of Mathematics.

Professor Dickson of the University of Chicago says in the preface to his History of the Theory of Numbers: "The efforts of Cantor and his collaborators show that a chronological history of Mathematics down to the nineteenth century can be written in four large volumes. To cover the last century with the same elaborateness, it has been estimated that about fifteen volumes would be required, so extensive is the mathematical literature of that period." Then Professor Dickson proceeds to use three volumes with a total of about 1500 pages to write the history of the theory of numbers. We thus see that the development of

Mathematics has been great and has increased rapidly in recent times and that the theory of numbers has been a field of wide interest to require so much space for a mere summary of the results as the Dickson History is.

One reason for the accelerated development of Mathematics has been the cooperation of mathematicians. New results are now published, other mathematicians read them, see something the author did not, or see how the new idea ties up with their own work, and this combining of ideas is fruitful in the production of new results. This was not always so. There were 950 periodicals publishing mathematical articles in the nineteenth century. There were none before 1665. Mathematicians formerly found new methods and then wrote their friends proposing problems that could readily be solved by the new methods. This was a sort of challenge—an intercollegiate intellectual competition. There are many instances of such challenge problems in the literature. I shall give you one example.

In 1643 Fermat wrote a letter to Mersenne which is preserved. In the last paragraph Fermat writes: (Translation). "You asked me whether this last number (100,895,-598,169) is prime or not and to give a method by which one could discover in the space of a day whether it is prime or composite. I reply that the last number is composite and is the product of the two numbers 898,423 and 112,303, which are prime.

I am always, my Reverend Father,

"Your humble and very affectionate servant,

FERMAT."

But there is no hint as to how it was done.

I am going to give you a few quotations to give an idea of what men who have contributed to our knowledge have to say about the subject of their interest.

Robert Boyle: "Arithmetic and geometry, those wings on which the astronomer soars as high as heaven."

Kronecker: "God made integers, all else is the work of man."

Gauss: "Mathematics is the queen of the sciences and arithmetic the queen of mathematics. She often condescends to render service to astronomy and other natural science, but in all relations she is entitled to the first rank."

Now one from a pessimist. Robert Recorde (from his Algebra which he called the "Whetstone of Witte," printed in 1557): "Wherefore to conclude, I see more men to acknowledge the benefit of number, than I can espy willing to study, to attain the benefits of it."

G. H. Hardy (from his inaugural address when installed at Oxford University): "What we do may be small, but it has a certain character of permanence; and to have produced anything of the slightest permanent interest, whether it be a copy of verses or a geometrical theorem, is to have done something utterly beyond the powers of the vast majority of men."

I cannot refrain from giving, at this technical school, a remark of that preeminent disciple of utilitarianism, Benjamin Franklin. In a letter published in 1769 we find, "I then confessed to him that in my younger days, having once some leisure (which I still think might have been employed more usefully) I had amused myself in making these kind of magic squares, etc." The rest of his letter shows that it was a considerable amount of time thus spent. There must have been a great attraction to this intellectual diversion to keep Franklin so long from useful occupations.

Again from Gauss: "The higher arithemetic presents us with an inexhaustible store of interesting truths, of truths too which are not isolated, but stand in a close internal connection, and between which, as our knowledge increases, we are continually discovering new and sometimes wholly unexpected ties. A great part of its theories derives an additional charm from the peculiarity that important propositions, with the impress of simplicity upon them, are often easily discoverable by induction, and yet are of so profound a character that we cannot find their demonstration till after many vain attempts; and even then, when we do succeed, it is often by some tedious and artificial process, while the simple method may long remain concealed."

I am not giving these quotations to justify my interest in numbers. A subject that has held the interest of thinking men for more than two thousand years and still holds it requires no apologist.

As an example of the interest in mathematics beyond the professional interest I want to tell you a little about the

society founded at Spitalfields in 1717. At the beginning its membership was made up for the most part of silk weavers of French extraction. It was in reality a working man's club at which questions of mathematics and natural philosophy were discussed every Saturday evening. Membership was limited to the square of seven, later to the square of eight, and still later to the square of nine. The dues were sixpence a week and the card of admission was a metal ticket which had the proposition of Pythagoras engraved on one side and a sighted quadrant with level on the other. By the constitution it was the duty of every member if he were asked any mathematical or philosophical question to answer to the best of his ability. Each member in turn had to lecture or perform experiments. They had refreshments at club meetings in those days also. The dues entitled each member to a pint of beer and each five members might call for an extra quart. But the refreshments were not the chief purpose of the club. It needed no such excuse in those days. The society got into trouble about 1823 and had to defend itself in the courts. And you never could guess the reason. They were putting on scientific lectures and admitting the public at a shilling a head. And people came and paid. And there is where the trouble started. They were putting on entertainments to which an admission was charged and they had no license. The society won. Imagine the scientific groups of the University competing successfully with the movies as attractions for paying crowds.

The problem and answer departments of many non-technical journals during the eighteenth and nineteenth centuries is also evidence of a wide interest in arithmetic among people in general. Professor Miller quotes from "The Ladies' Diary" of 1710 the following problem and answer in rhyme:

QUESTION.

"A farmer with a plowman doth agree
That thirty days his servant he should be.
Each day he wrought the farmer is to pay
Him sixteen pence; but when he was away
Five groats he is for each day to abate.
The time expir'd; they their accounts do state.

Whereby the master nothing is to give,
Nor has the servant any to receive.
How many days he wrought I do demand,
And how many he play'd I'd understand."

ANSWER.

"That lazy drone who squander'd away
Thirteen days and one third in sleep and play,
In thirty days (for all he nothing got)
Deserv'd to have his bones broke, for an idle sot."

Why this interest in numbers extending from the time of Euclid or before down to the present? I think there are two chief reasons. The first is the fact that everyone is familiar with and has to do with numbers. We meet them everywhere. The second reason is that so little preparation is needed to work in many parts of the field of number theory. If you want to solve differential equations, you must know arithmetic, algebra, trigonometry, analytic geometry and the calculus. But many parts of number theory are open to the student who knows his arithmetic and algebra.

An example of how one may run onto an apparent fact by experiment is given by the following: Take any number, say 69, add to it the number formed by reversing the order of the digits, 96; treat the sum in the same way; if this is continued you eventually come to a result which reads the same forward or backwards. If you start with 89, after twenty-four operations, you arrive at 8,813,200,-023,188. Is this true of every number? This problem was proposed in the American Mathematical Monthly about 15 years ago and so far as I know has never been proved.

$$
\begin{array}{r}
69 \\
96 \\
\hline
165 \\
561 \\
\hline
726 \\
627 \\
\hline
1353 \\
3531 \\
\hline
4884
\end{array}
$$

I want to speak now of some special numbers that have interested people for a long time—perfect numbers, multiply perfect numbers, and amicable numbers.*

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*Historical statements about these numbers following are from Dickson—History of the Theory of Numbers.

PERFECT NUMBERS.

A number which equals the sum of its divisors, not including the number itself, is called a perfect number. For example, $6 = 1 + 2 + 3$, $28 = 1 + 2 + 4 + 7 + 14$. Or if we include the number itself among the divisors we say that a number is perfect if the sum of all its divisors is twice the number.

Perfect numbers have been known for a long time. Professor Dickson gives more than two hundred references to the subject. Euclid was interested and in fact showed that if a number is of the form

$$N = 2^{n-1} (2^n - 1)$$

where $2^n - 1$ is prime then the number N is perfect. It has since been proved that every even perfect number is of this form. It has neither been shown that an odd perfect number is impossible nor has one been found. The difficulty in finding perfect numbers is in proving the numbers of the form $2^n - 1$ prime. This has been done only in the cases $n = 2$, 3, 5, 7, 13, 17, 19, 31, 61, 89, 107, 127. The corresponding numbers are 6; 28; 496; 8,128; 130,816; 2,096,128; etc. So you see there are not many small perfect numbers. But few as they are they have created much interest and the search for perfect numbers has produced a considerable amount of material on the matter of testing numbers to find if they are prime.

II Kings 13:19 is cited by some to show that the early Hebrews considered 6 a perfect number. "And the man of God was wroth with him and said, Thou shouldst have smitten five or six times; then hadst thou smitten Syria till thou hadst consumed it: whereas now thou shalt smite Syria but thrice."

Iamblichus (about 283-330) said that the Pythagoreans called the perfect number 6 marriage, and also health and beauty.

Aurelius Augustinus (354-430) remarked that, 6 being the first perfect number, God effected the creation in 6 days rather than at once, since the perfection of the work is signified by the number 6.

Alcuin (735-804) of York and Tours thought 6 associated with the creation because it is a perfect number. There were 8 on Noah's Ark and 8 is not perfect, since $1 + 2 + 4 + 8 = 15$, which is not twice 8, and hence the second origin of the human race was not so perfect as the first.

Rabbi Ankin, at the end of the twelfth century, recommended the study of perfect numbers in his book "Healing of Souls."

MULTIPLY PERFECT NUMBERS.

It was not until about 1631 that we find Mersenne, a French mathematician, interested in multiply perfect numbers. If the sum of all the divisors of a number is an integer times that number we call it a multiply perfect number. For example the sum of the divisors of 120, $1+2+3+4+5+6+8+10+12+15+20+24+30+40+60+120=360=3\text{x}120$. The multiple of the number is called its multiplicity, e. g., 120 is a multiply perfect number of multiplicity 3. From the time of Mersenne, Fermat, and Descartes there has been occasional interest in this subject and about 50 such numbers were published.

In 1911 Professor Carmichael, now of the University of Illinois, and I published a list of multiply perfect numbers which included about two hundred new numbers of multiplicities 4, 5, 6 and 7. Our list contained the first published multiply perfect number of multiplicity 7. These numbers are very large, e. g., $2^{75}.\,3^{21}.\,5^{6}.\,7^{9}.\,11^{5}.\,13.\,17^{2}.\,19^{3}.\,23.\,37.\,43^{2}.\,67.\,79^{2}.\,97.\,107.\,139.\,181^{2}.\,191.\,199.\,229^{2}.\,257.\,307.\,331^{2}.\,457.\,467.\,631.\,661.\,2617.\,2801.\,3851.\,5233.\,11939.\,19531.\,43691.\,174763.\,262657.\,524287.\,525313.$

This is rather a large number and if multiplied out would have 159 digits. I have not multiplied it out. It has 137,420,957,-559,029,760 different divisors, counting itself and unity, and their sum is exactly 7 times the number.

AMICABLE NUMBERS.

Two numbers are amicable if the sum of the divisors of each, not including itself, is equal to the other number. For example, the sum of the divisors of 220, not including 220, is
$$1+2+4+5+10+11+20+22+44+55+110=284,\quad \text{and the}$$
sum of the divisors of 284, not including 284, is
$$1+2+4+71+142=220.$$

Magical properties were attributed to amicable numbers. Iamblichus in the early part of the 4th century said that the Pythagoreans call certain numbers amicable "adopting virtues and social qualities to numbers, as 284 and 220, for the parts of each have power to generate the other, according to the rule of friendship, as Pythagoras affirmed. When asked what is a friend, he replied 'another I', which is shown in these numbers. Aristotle so defined a friend in his Ethics."

"Among Jacob's presents to Esau were 200 she-goats and 20 he-goats, 200 ewes and 20 rams (Genesis XXXII, 14). Abraham Azulai (1570-1643), in commenting on this passage from the

Bible, remarked that he had found written in the name of Rau
Nachshon (ninth century A. D.):   Our ancestor Jacob prepared
his present in a wise way.   This number 220 (of goats) is a hidden
secret, being one of a pair of numbers such that the parts of it
are equal to the other one 284, and conversely.   And Jacob had
this in mind; this has been tried by the ancients in securing the
love of kings and dignatories."

Other writers tell of giving some one, whose friendship is
sought, the number 220 and retaining the number 284.

In spite of this interest in amicable numbers this pair, 220 and
284, were the only ones known until about 1636 when Fermat
discovered another pair, 17,296 and 18,416.   According to E. B.
Escott, Descartes added another pair in 1638, Euler 59 in 1750,
Seelhoff two in 1884, Dickson 2 in 1911, Mason 14 in 1921, and
Escott 31 in 1930.   It becomes evident as you work with such
numbers that new pairs of amicable numbers can be found if
you have patience, some skill, and a good table of primes.
These number pairs soon become large.   I have also found sets
of three, four, five, and six numbers such that the sum of the
divisors of each number of the set is equal to the sum of the
numbers in the set.   For example the five numbers $17.79.a$,
$19.71.a$, $23.59.a$, $29.47.a$, $1439.a$, where $a = 2^{15}.3^5.5^2.7.11.43.257$,
have the property that the sum of all of the divisors of any one
of them is equal to the sum of all five numbers.

In dealing with perfect, multiply perfect, and amicable num-
bers it is necessary to know whether numbers are prime or com-
posite.   There are comparatively few of these numbers that are
small and it soon becomes necessary to know whether fairly
large numbers can be factored.   The search for perfect numbers
in particular has been the incentive to a great deal of research
on the testing of large numbers to find if they are prime.   Pro-
fessor Lehmer prepared a table of the primes up to ten million
and a table showing the larger factors of the composite numbers
up to ten million.   It was the publication of these tables about
twenty years ago that made the search for large multiply perfect
and amicable numbers possible and productive.   Thus a desire
to know about one thing brought about an increase of knowledge
of something else.

A Large Number.

The multiply perfect number presented a while ago may
have seemed large to you, but I am now going to introduce you
to a really large number.

About 1641 Fermat stated his belief that every number of the form $2^{2^n}+1$ is prime. About 100 years later Euler showed that the number for $n=5$ has the factor 641. So the guess of Fermat was wrong. In 1906 Moorhead showed that the number $2^{2^{73}}+1$ has the factor $2^{75}.5+1$ and that the latter is prime.

Let us look at this number. $2^{73}=9,444,732,965,739,290,427,-392$. Now consider raising 2 to that power. But a little device will help us some. $2^{10}=1024$ and $10^3=1000$. So if we replace 1024 by 1000 we can get along more easily and will have decreased our number. Now an example with smaller numbers of what we are to do. $2^{70}=(2^{10})^7$ which is greater than $(10^3)^7=10^{21}$. If we do similarly with $2^{2^{73}}$, we shall divide 2^{73} by 10 and multiply the result by 3 to get approximately the exponent of 10. That will give, calling all digits zero except the first two, $2^{2^{73}}$ is greater than $10^{2,800,000,000,000,000,000,000}$. But $10^3=1000$ and the result contains one more figure than the exponent. Neglecting the one, the number above, if written without the use of exponents, would contain $2,800,000,000,000,000,000,000$ digits. Let us examine the size of such a number. Let us print 50 digits to the line, 40 lines to the page, and 700 pages to the book. Each book would contain 1,400,000 digits. Dividing the number of digits by the number in a book shows that we should require 2,000,-000,000,000,000 books to print the number. If we put 1,000,000 books in a library, we would require 2,000,000,000 libraries; or something more than a library of a million books for each man, woman, and child in the world. Here is a number which the whole human race working continuously could not write down in a thousand years. Can you visualize that?

But it is not the size of this number that is the marvel. The marvelous thing to me is that man has developed his intellect until he is able to say that this number has a divisor, and that the smallest divisor is 188,894,659,314,785,808,547,841 and that this is a prime number.

We have mentioned prime numbers frequently. Let us consider them briefly.

SOME THINGS WE KNOW ABOUT PRIMES.

Euclid proved that there are an endless number of primes. His proof is not difficult. Let us suppose that there is a limited number. Then there is a largest prime, call it p. Then form the product of all the primes up to and including p and add 1 to the product, thus $M=(2.3.5.\text{---}p)+1$.

If we divide this number M by p or by any prime less than p, we have a remainder of 1.   Hence M is itself prime or has a prime divisor which is greater than p.   In either case our assumption that p was the largest prime is incorrect.   If there is no largest prime than there is an endless number of them.

Tchebychef has proved that for numbers greater than 3 there is always a prime between a number and two less than its double. This shows that the primes are distributed and not bunched. Yet by going far enough into the large numbers we can find gaps where there are no primes.   We can find as large a gap as we want if we go far enough.   For example, if we want to find a place where there is no prime among a million consecutive integers we proceed as follows:

Multiply together all the primes up to and including the one next larger than a million.   Call this product P.   Then the numbers

$$P+a,$$

where a takes the values from 2 to 1,000,001, are all composite. For if a is a prime that prime is a factor in P and hence $P+a$ is divisible by a.   If a is not a prime its prime factors are factors of P and $P+a$ is not a prime.   Hence we have at least 1,000,000 consecutive numbers without a prime.

Dirichlet proved that every arithmetic series of the form $a+nd$, where a and d are integers which have no common divisor except unity and where n takes successively the values $0, 1, 2, 3, —$, contains an unlimited number of prime integers.   This says nothing about how often they occur but only that they are there.

SOME THINGS WE DO NOT KNOW ABOUT PRIMES.

There are many things we do not know but I shall state only a few.   We have never been able to devise a formula that will always give primes.   The formula of Fermat, $2^{2^n}+1$, breaks down when $n=5$.   The formula, n^2-n+41, gives primes for $n = 0, 1, 2, —, 40$ but fails for $n=41$.

We have never been able to find a formula that will give the number of primes less than a given number.   We do, however, have an expression for the number of integers less than a given number that have no factor in common with the given number.

Goldbach stated in a letter to Euler about 1742 that every even number is the sum of two primes, if you consider unity a prime. This has not been proved.   The only real attack on the problem has come in recent years by Hardy and his co-workers at Oxford.

If they assume a generalized form of Riemann's conjecture about the zeros of the zeta-function they can prove that every odd number from a certain point on can be expressed as the sum of three primes. This does not prove Goldbach's theorem but is significant in that it is the first real start toward a solution in nearly two centuries of effort.

There are many pairs of primes differing by two, such as 11 and 13, or 29 and 31. Are there an indefinite number of such? No one knows. No one even knows whether it is possible with our present state of knowledge to tell the answer.

Is there a prime number between consecutive square numbers? There seems to be, but no one has yet proved it.

These problems are not difficult to state. But no one is able at present to say whether the proofs are easy or difficult. We do know that they have not yielded after many attacks by well equipped men. Will they ever be solved? We do not know. But we do know that the intellectual curiosity of man will not let them rest in peace. They are challenges to man's ability and he will not rest until he has conquered.

I want to tell you now about two of these problems, whose challenge has brought results.

Two Noted Problems in Number Theory.

We are familiar with examples of the sum of two squares being equal to a square, such as

$$3^2 + 4^2 = 5^2, \ 5^2 + 12^2 = 13^2, \ 9^2 + 40^2 = 41^2.$$

After the death of Fermat it was discovered that he had written on the margin of his copy of Diophantus that it was impossible to separate a cube into the sum of two cubes, or any higher power, into the sum of two like powers, and added, "I have discovered a truly remarkable proof which this margin is too small to contain."

In the years since, the statement has been proved true for many cases, but has never been proved in general. More than twenty years ago a prize of 100,000 marks (about $25,000) was offered for its solution. This prize money drew the efforts not only of mathematicians but of many whose knowledge of mathematics was in no wise equal to their desire for the money.

The efforts to solve this last Fermat problem added many valuable results in the theory of numbers although they have not accomplished the solution of this particular problem. It is probably a case where results accomplished are worth more than a solution of the problem would have been.

In 1782 Waring stated that every number is the sum of not more than four squares, not more than nine cubes, not more than nineteen fourth powers, and in general that any number is the sum of k − th powers, the number of such powers depending only on k.   This was only a conjecture on his part.   It did not necessarily require any deep knowledge of the subject.   It is a case of experiment.   If you try to build up a number as the sum of squares and discover that in every case you try it requires no more than four, you will soon guess that you have found a property common to all numbers.   The numbers 23 and 239 are the only numbers known that require as many as nine cubes. You see then that experiment would soon set upper bounds to the least number of powers required.   While it is easy thus to determine an approximate upper bound to the number of terms required, the proof that you have the exact limit is another matter altogether.   Waring's conjecture has been proved true for squares and cubes.   For fourth powers the limit is 19, 20, or 21. The efforts at proof have shown that if you take sufficiently large numbers you do not need nine as your upper limit but that four or five is the number of cubes required.   But of more importance, than the correct answer to the question, is the provoking into activity the ingenuity of men to invent new machinery or to use old ideas in a new way to attack the problem.

And that is why these two problems have been presented to you. It was the attempt to solve the Fermat problem that led Kummer to invent his ideal numbers, the use of which has made possible the general theory of Algebraic numbers, a most important branch of modern methematics.

Following the invention of the calculus there was a considerable development in the theory of functions and with the rigorous methods of argument supplied by Weierstrass and his followers, analytic functions came to be an important tool.

But the methods of analysis worked well only so long as our variables changed continuously, or jumped occasionally.   The integers go only by jumps.   Hence one of the most powerful tools of modern mathematics could not be used in number theory.   But Hardy and Littlewood found a way to use their knowledge of analytic functions in the case of the Waring problem.   So that it is better, after all, that Fermat could not write down his proof on the margin of his book and that Waring could give no proof of his statement.   The solutions of these problems are much less valuable than the new theory and new

methods of using the tools of analysis which their challenge as unsolved problems has inspired.

Let me conclude with a quotation from Hilbert: "The theory of numbers is a magnificent structure, created and developed by men who belong among the most brilliant investigators in the domain of the mathematical sciences... Morever, the theory of numbers is independent of the change of fashion and in it we do not see, as is often the case in other departments of knowledge, a conception or method at one time given undue prominence, at another suffering undeserved neglect; in the theory of numbers the oldest problem is often today modern, like a genuine work of art from the past."

A STUDY FOR THE TEACHER WHO WISHES TO INVENT AN ALGEBRA PROBLEM.

By William F. H. Godson, Jr.,

Chestnut Hill Academy, Philadelphia, Pa.

If you wish to reverse the digits of a two digit number so that the resulting number will be less than the original number by some given quantity you must avoid certain combinations of values, shown by means of a formula explained herewith, as these combinations give more than one result, and the two simultaneous equations arising from the statement of the problem are identical and give no solution. (If the problem is solved by means of one equation, an alternate method in such cases, this equation reduces to an identity also.)

FORMULA: $(T-U)(t+u) = 10t+u$
Where: T is the 10's digit) of the required number.
U is the unit's digit)
and, t is the 10's digit) of the difference between the re-
u is the unit's digit) quired number and that number
with the digits reversed.

TECHNIQUE:
1. Proposed problem: In a certain number the 10's digit is 4 more than the unit's digit. If 36 be taken from the number the result will be a number which has the digits of the original number reversed. Find the number.
2. Test the proposed problem in the formula.
   (a) Quantities: $T = x+4$
   $\quad\quad\quad\quad\quad\quad\quad U = x$
   $\quad\quad\quad\quad\quad\quad\quad t = 3$
   $\quad\quad\quad\quad\quad\quad\quad u = 6$
   (b) Formula: $(T-U)(t+u) = 10t+u$
   (c) Substitution: $4 \cdot 9 = 30+6$, or $36 = 36$.
   (d) Conclusion: As the formula reduces to an identity the proposed problem will also result in an identity and cannot be solved.
   (e) Discussion: Possible solutions however (by inspection): 95, 84, 73, 62, 51, and (if 0 be used) 40.

THE FORMULA RE-STATED: If (under the terms of the problem) the product of the difference of the digits of the number to be found, by the sum of the digits of the number to be taken away, equals the number to be taken away, the answer is indeterminate.

ARTIFICIAL CRUTCHES IN TRADITIONAL SCIENCE TEACHING.

By JOSEPH M. JAMESON,

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It is the thesis of this paper that the selection and organization of subject matter in science for secondary schools have not been sufficiently controlled by those who teach it. As a result, after many years of effort on the part of these teachers, science finds itself in the place that it now very generally occupies in the curriculum of the secondary school—a place that it is likely to continue to occupy unless we have in these schools less emphasis upon research in science and more attention to research in science teaching.

It is not necessary to argue the place of science in education. We know that running a home, getting to our place of teaching, communicating with our fellowmen, preserving our own health and that of our community and in short engaging intelligently in any and all of the numberless contacts and processes of present day life involve the acceptance and utilization of an almost overwhelming mass of facts and applications of science with which the preceding generation had no occasion or opportunity to deal. Those interested in science teaching, share, I assume, the conviction that human welfare, human happiness and human progress are very greatly dependent upon the continued unfolding of the divine plan by the discovery of truth through scientific research. They agree, I also assume, with Dr. Robert A. Millikan* that: "As soon as the public learns, as it is slowly learning, that science, universally recognized as the basis of our civilization, knows no such thing as change for the sake of change, as soon as the public learns that the method of science is not to discard the past, but always to build upon it, to incorporate the great bulk of it into the framework of the present, as soon as it learns that in science truth once discovered always remains truth, in a word that evolution, growth, not revolution, is its method, it will, I hope, begin to banish its present craze for the sensational, for the new regardless of the true, and thereby atone for one of the sins into which the very rapid growth of science may have tempted it."

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*Scribner's Magazine, February, 1930.

But the planting of desirable ideas in the mass-mind is a slow sort of gardening. We may not be in 1930 in quite the situation revealed by the minute of the School Board of Lancaster, Ohio, in 1828, which removed any necessity for further mental unrest in the community by the solemn dictum, "You are welcome to use the schoolhouse to debate all proper questions in, but such things as railroads and telegraphs are impossibilities and rank infidelity. There is nothing in the Word of God about them. If God had designed that His intelligent creatures should travel at the frightful speed of fifteen miles an hour, by steam, He would have clearly foretold it through His holy prophets. It is a device of Satan." Yet, after the progress of a hundred years, we not infrequently find that, as Dr. Slosson so aptly says: "In actual life ignorance is called conservatism, and the combination is a strong one. In order to introduce a new idea into the mind of man it is generally necessary to eject an old idea. To move in new furniture one has first to move out the old."

We may confidently expect that research will go on, that new truths will be revealed, that we shall not fail to have leaders in scientific thought, but whose particular business shall it be to "move out the old furniture" and thus to prepare the public mind to react properly upon the new as it appears, and where shall those responsible for this great service find their most natural and fruitful place of work? It scarcely needs to be stated that the great majority of the public will continue to end their educational career in the high school. The average citizen will continue to acquire in the high school, if he acquires them at all, those habits of mind by which he properly relates himself to the age in which he lives. He will continue to be a ready prey to half-truths and falsehoods, his judgment will fail to be critical, and he will be ready to accept any statement made with sufficiently impressive vigor just so long as his high school education fails to equip him for the right use of his mind in weighing evidence and reaching right conclusions. Hence the importance of a proper kind and a proper sequence of science teaching in secondary schools.

The 1920 report of the special committee on science of the Commission on The Reorganization of Secondary Edu-

cation presented the need for new objectives in science teaching and for a coherent and cumulative sequence of science subjects, each building upon the preceding. This report has been widely circulated and unquestionably has been instrumental in bringing about many improvements in science teaching. Yet a study of state requirements for high school graduation by Carl A. Jessen, Specialist in Secondary Education, United States Office of Education, shows that a year's work in elementary science is required in five states, that three other states give an option between general science and biology or physiology, and that only twenty-six states require one or more years of science for graduation, whereas forty-one states require English, and forty states require some credit in history or other social sciences before graduation. This comparison is not made with the thought of attacking the validity of these requirements for English and the social sciences but rather to contrast the recognition of English and of the social sciences with the recognition of science as a fundamental or "core" subject. A study by the same authority of the requirements of the schools shows nearly the same relative emphasis upon these subjects and also that mathematics is more frequently required than is science.

This failure in a scientific age to enforce an adequate content of science instruction for high school graduation is further affected by the system of elections usually followed. In many school systems, two terms of science are required for graduation from high school. This requirement may be met by general science alone. A report by Earl R. Glenn at the recent meeting at Atlantic City of the National Association for Research in Science Teaching, from data obtained with four groups of high school seniors or graduates, revealed the following rather startling evidence of the lack of a coherent plan in science elections:

Group	Number in the group	Number of different combinations of Science subjects found
1	218	33
2	280	42
3	310	72
4	550	83

Of five hundred and fifty students entering one college, twenty-eight had studied no science, one hundred and sixty-

two had had one year of science, forty-eight had had one and a half years, one hundred and four had had two years, forty-three had had two and a half years, eighty-five had had three years, thirteen had had three and a half years and thirty-one had had four years. The variations and inconsistencies in the combinations of science elected by these five hundred and fifty students were quite as startling as in the cases of the groups mentioned in the preceding paragraph. Data secured by R. J. Coats, and quoted in the report just referred to, give the following as the chief reasons why one thousand high school seniors in the Detroit public schools had not elected science: "Thought it was too hard;" "Thought I was too poor in mathematics;" "Was advised by my principal or counsellor not to take it;" "Was advised by students not to take it;" "Because I thought I would never need it;" "No time for it, program too full."

In general, recognizing notable exceptions here and there, it must be admitted that science teachers in secondary schools have failed to "sell" their subject either to school executives or to pupils. It is true that science as a newer subject has had its way to make against a rather fixed bias in favor of subjects already well established, but the fundamental reason for failure to secure greater recognition for science, I believe to be the fact that, as already stated, these teachers have not assumed control over the content and methods of the science they have attempted to teach. They have leaned too heavily upon artificial "crutches" handed to them through tradition and by those who have been thinking in terms of the science of formal courses in institutions of higher learning. These crutches have, in the accumulations of a long period, not only not aided true progress in elementary science teaching, but in the end have been an actual deterrent to progress.

The first elementary texts in physics, for example, and the first plans for the teaching of physics in secondary schools by the laboratory method were based upon the ideas of college men. Such teachers naturally spoke with authority and reputation to teachers who had learned their physics under their tuition. But while qualified specialists in the facts and laws of physics, they were not necessarily also qualified specialists in the natural interests of young people

and the functioning of the untrained mind. Started in the wrong way, and carried forward to the present by the influence of authority and tradition, physics text books and physics teaching in the high school are still very generally dealing with subject matter on the *logical plan*—that is to say they are concerned primarily with abstract generalizations, principles and definitions. Concrete problems and applications follow (if there is time). The same statement is true in an almost equal degree of chemistry and biology. The sensible and *teachable* organization of science for young pupils rests upon the environment and experiences of the pupils themselves rather than upon those interests which obtain in the world of the trained scientist. These young people may eventually dwell in that more specialized world; if born scientists they will come through safely and we need not worry unduly. But how about the average pupil who is not to be a scientist but who must live, and we hope intelligently, in a scientific age?

In grasping a new idea, the mind does not proceed from the general to the specific, from the abstract to the concrete, but quite in the opposite direction. In other words, principles and definitions do not come first and applications afterward. The secondary school science teacher must start at the pupil's own level, and then, in the process of finding answers to the problems which really interest young people, the larger fundamental principles of the science will emerge.

Laboratory experiments were and still are, largely for the determination of some particular constant or some special quantitative value. They have been directed toward a rather specialized end instead of toward the uncovering of broader underlying principles. Because of this, an artificial type of apparatus has often been devised, associated only with the laboratory and never encountered in, or perhaps even thought of as concerned with, real life. To teach accuracy and precision, attempts have often been made to obtain data quite beyond the powers of an untrained scientist, and figures have been retained which not only are not significant but which were both misleading and untrue. Any fascinating and perhaps really illuminating idea that might tend to stand forth has not infrequently been quietly

smothered under a bewildering mass of computation. Taking stock of past and present laboratory practice and thinking in terms of normal young people can one imagine pupils enthusiastically electing more work of the same sort?

A second, and perhaps the worst artificial crutch of all, has been the so-called "even front" method of experimentation by which the investigation is reduced to the trivial size and character that may be duplicated for the thirty or more pupils making up the class. Revolt against this method has spread rapidly of recent years. Many teachers are reducing pupil laboratory work and resorting increasingly to the lecture demonstration method of presentation. Discussions of the relative values of the two procedures, and attempts to devise tests by which to measure the efficiency of each as a teaching method are appearing in increasing numbers.

It is regrettable that more attention is not being given to a third method which retains many of the advantages of both the lecture demonstration, with its better focus and its saving in time, and pupil experimentation, with its content of personal manipulation of apparatus and its demand for individual initiative. Lacking a more descriptive term, let us call this the lecture-laboratory or the group experiment method. For more than ten years we have been developing this procedure with the classes in physics at Girard College and, to a lesser degree but with equal satisfaction, for certain portions of the work in biology and chemistry. We have been endeavoring to equip our physics laboratory with certain large-type outfits, not necessarily elaborate in character or expensive to procure.

These group equipments are set up and operated under the supervision of the teacher. Certain members of the class are appointed to read the instruments or make the necessary measurements, others to act as record keepers. Data are entered on a properly ruled and headed blackboard form in view of all the class. Full readings for the experiment desired are taken, and from the common data each student writes up his report, plots his curves or makes his computations and draws his conclusions. The problem being stated orally and briefly planned in advance, time is saved because detailed direction sheets are not necessary.

By assigning different pupils in turn to take readings and measurements, or to record the data, each pupil gains practice in the manipulation of apparatus and learns to read the instruments or measuring scales employed and properly to record experimental data. The exercise is guided by the teacher, as is a lecture demonstration, but the added values are obtained of pupil participation and of a general discussion of results in which all members of the class may engage, as all have the same data.

The results obtained at Girard College by this lecture-laboratory method have been compared with the results formerly obtained with the old type of laboratory instruction through the use of standard achievement tests, of tests developed by our own staff and of College Examination Board tests. Our experience is that more subject matter can be covered in a given period, and also that the boy taught by the lecture-laboratory method is better prepared, has a keener grasp of facts and principles and is more resourceful in discussion and in drawing correct conclusions. In addition class interest is keener, and the consideration of the larger project first commonly leads to interesting queries which may be used for supplementary individual laboratory experiments, thus still further introducing the desirable element of pupil participation.

A word should perhaps be said here regarding the special adaptability of the lecture-laboratory method to small high schools. Science instruction in these schools is often limited or omitted because of a feeling that effective teaching requires an elaborate laboratory equipment. The farm or small community boy or girl has special need for a practical and concrete training in science. By the group method, the resourceful teacher may secure commendable results with a few accessories in the way of measuring instruments and a limited supply of practical equipment collected by the pupils or constructed at small cost in local shops.

A third crutch imposed by tradition and by those outside the teaching group of the secondary schools is a false interpretation of thoroughness in science teaching. Thoroughness, if it signifies mastery, can not be too greatly desired or too strongly commended, but that so-called thoroughness which overloads the science courses of the high

school until the outcomes of these courses can be but little more than partly comprehended information is opposed to the basal values of science education. Too frequently the fact that science deals with the material elements and processes of the world is interpreted as meaning that science has nothing to contribute to the education of youth but immediately usable information. Science is richer in cultural and disciplinary values than in immediate, practical applications. But these cultural and disciplinary values can not be realized by skipping hastily from topic to topic in order that no part of a seven hundred page text book be omitted. They depend upon the mastery of fundamental concepts, laws and principles and upon growth in mental power, upon the establishment of mental attitudes and upon the fixing of valuable habits of thought. They can be realized only when a definite and vigorous reaction can be obtained from the pupil. Obviously, therefore, the teacher who, yielding to influences imposed upon him, overcrowds his science courses thereby defeats the chief purposes of science teaching. Far more desirable results would be obtained by attempting to teach only so much subject matter as can be taught properly, keeping in mind all of the valuable outcomes of science instruction. The pupil would then emerge from the high school with some permanent accomplishment in establishing mental attitudes and habits of thought. He would be oriented in some degree in a scientific age, and therefore would be likely to become a safer and more valuable citizen.

In conclusion, the writer desires to disclaim any tendency toward pessimism. To be critical of the accomplishment of the past is not necessarily to express doubt as to progress in the future. It is contended that science is an essential "core" subject for the high school curriculum, and that, at the present time, it does not hold such a position either in the plans of school executives or in the estimation of high school pupils. It is contended that a proper sequence and amount of science instruction must be definitely agreed upon, as the present system of science electives is failing to secure either. It is further contended that traditional practices in science teaching should be subjected to a rigid study by those informed as to the learning processes of

immature minds, and that, as an outcome of such research, a desirable content should be built up of both methods and material for science instruction in secondary schools.

The problem, while it will require time, does not appear necessarily difficult of final solution. The desired answer is dependent mainly upon an application of the old maxim of good teaching, "teach the pupil and not the subject." Leadership, as has already been demonstrated in many quarters, is available from schools of education, and from those elsewhere who have an abiding interest in science education. The more fortunately situated teachers of science in secondary schools can furnish the places and the personnel for experimental studies in teaching procedure. Through cooperation, the findings established in these schools may be made available to all. And, if those actually upon the firing line in the teaching of science in secondary schools, will thus work out the problem for which they alone possess the means for a satisfactory solution, it is predicted that they will have the sympathetic interest and cooperation of those engaged in science teaching in the colleges and universities. Those who deal with the selected few being educated for leadership will surely place a higher value upon aroused and inquiring minds as a preparation for advanced science education than upon a store of mere information; they, too, have an interest in the larger group whose formal education must end with the high school.

A VALUABLE TOOL FOR GEOLOGISTS.

The bibliography of North America geology for the ten years 1919-1928, just issued by the United States Geological Survey as Bulletin 823, is an almost indispensable working tool for geologists in active service. It lists publications on the geology of the continent of North America and the adjacent islands, Panama, and the Hawaiian Islands. The main list is arranged alphabetically by authors and is followed by a very full index to the literature cited. This volume supplements Bulletins 746 and 747, which covered the same ground for the years 1785-1918, and the three bulletins therefore afford a complete picture of the vast amount of study that had been given to North American geology to the end of the year 1928. Bulletin 823 contains over 1,000 pages and may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for $1.25.

SOME LESSONS ABOUT BEES.
BY T. P. WEBSTER, M. A.
Allegheny Vocational School, N. S. Pittsburgh, Pa.

HOW I TEACH THE LESSONS.

The lessons are furnished each student on mimeographed sheets. A single frame observation hive containing a frame of live bees is brought into the class room for one of the periods.
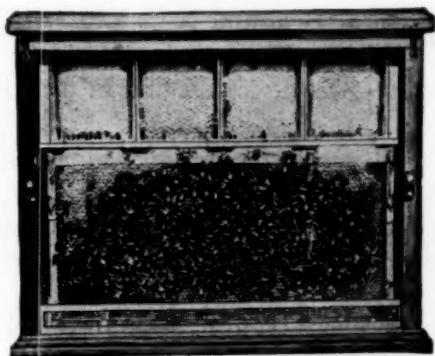
OBSERVATION HIVE.

As this hive full of safely imprisoned bees weighs only a very few pounds, it may be easily passed from student to student.

Such a hive may easily accommodate two or three thousand bees. Being imprisoned, these bees will always demonstrate their system of ventilation described under "Ripening Honey."

Fig. 116.—Small Benton Cage 2-3 size).

A QUEEN CAGE.

The live queen can best be shown in a queen mailing and introducing cage, which will accommodate a queen and a half dozen workers.

Live drones may be shown in another cage. These cages may be purchased at four cents each. A local bee keeper who has honey to sell will usually, for the sake of advertising, be glad to loan you the bees and queen for a day. If he has no observation hive you might have the woodworking classes make one. Direction for hive making may be found in the "A B C and X Y Z of Bee Culture" by A. I. Root.

This is a standardized work found in practically all public libraries.

In addition to the live bees, the writer has Riker specimen mounts (glass covered cardboard cases) in which are displayed actual specimens of the bee's craft, i. e., wax cells of workers, drone and queen size in different stages of construction.

Dead workers, drones and queens are displayed. In one case are a large number of the pearly wax scales, just as they are secreted from the bee's body. They are placed under the glass on black paper, so they may be easily visible. These specimens, the queen excepted, should be easily obtained without cost, if the teacher furnishes the Riker mounts.

As the student reading aloud comes to a statement in the lesson needing explanation, a sample of the workmanship in question is usually available in one of these cases. It is passed around the class for inspection.

LESSON I, DIVISION OF LABOR.

1. *Nursing.*

Nursing as a vocation usually begins about one day after the worker emerges from the cell a full-fledged bee. As soon as the egg hatches the young larva is given forty times its own weight in food. The larva floats or swims in this food and increases in two days to 46 times its weight at hatching. The larval food supposedly made up of pollen and honey is partially digested by these young nurses. By the end of the third day it has increased 245 times its weight at hatching. After the second day it is fed only

such amounts of food as it can consume at once and is therefore fed many times. When the bee is about four and one half days old it weighs about 1500 times its weight at hatching. At this time it is given its last rations as a larva and the cell is sealed up. All this work of nursing has been done by bees under one month old. Nurses make an average of 1300 visits a day to each cell from the time the egg is laid in it until the larva reaches maturity, or 10,000 visits during the period of seven or eight days. This figure does not include numerous calls of inspection when at a glance the nurse apparently determines that all is well within the cradle and goes on. The 10,000 visits mentioned above mean feeding visits lasting from two seconds to three or four minutes. The number of visits are few and short on the first and second days, especially on the second, since the larva is supplied with such a large amount of food at the start. After the third day the visits increase in number and length. The total time given by the nurses to a young larva is 6.57 per cent of the lifetime of the larva, but the demands of the larva so increase as it grows older that, on the fifth day, the nurses actually spend 19.68 per cent of this day in its cell, approximately four and three-quarter hours, involving no less than 2,855 visits.

2. *The Ladies In Waiting To The Queen.*

Before mating a queen hunts up her own food from the combs; but after she begins to lay she turns to the workers for virtually all her food. Once in a great while she will dip her tongue into a cell of honey but not often. As she goes about her only duty of egg-laying, from time to time she crosses antennae with workers. Finally a worker is found with a supply of food; the worker's mouth opens and the queen inserts her tongue and begins to eat. The worker's tongue is kept folded behind the head. It is quite common to see several other workers extend their tongues and try to get a taste of the food, and sometimes one will succeed in putting her tongue in with the queen's. It is not at all unusual to see two workers getting food thus from another worker, and the drones obtain their food in the same way.

Sometimes a queen of poor stock does not grow as large as the normal queen. Such a queen beekeepers often re-

place with a better queen. Being so small that it is hard to find her, the beekeeper depends upon the peculiar behavior of the bees toward her to enable him to distinguish her from the workers. Ordinarily a queen is easily found because of her great size and light color. Much of the time her retinue of workers surrounds her, each bee keeping her head toward the queen and while she is still enough, stroking and caressing her.

3. Nurses To The Drones.

The tiny worm which is to be the future drone is fed for about a week instead of 4½ days as with the worker. It is then capped over like a worker larva, except that the cap to the cell is raised considerably more. The young drones begin to cut the caps of these cells in about 24 or 25 days. The caps come off in a round piece. Especial attention is called to the fact that drone eggs are placed by the queen in larger cells than are worker eggs, and that drone larva are fed two and one half days longer than worker larva before being sealed. The drone which is a male bee has no sting, no pollen basket and its tongue is unsuited to gathering nectar so that he might starve to death in a blooming clover field if left to his own efforts.

4. House Cleaning.

The young bees also act as house cleaners or sweepers. Any foreign substance which a bee can move, such as a blade of grass or a dead insect as a bee or ant, will promptly be carried out. Strings or pieces of cloth too large to be moved will be chewed up and made small enough to be carried out. The springtime is the favorite housecleaning time. The winter accumulation of debris may be seen dumped out over the front door step most any early warm spring day. Workers very frequently carry dead bees a long ways on the wing before dropping them. Most bees die outside the hive and so save the workers this trouble. Recent investigations show that about 98 per cent of the deaths of a colony occur in the field. Ailing bees often spend their last bit of strength in crawling outside the hive to die. The last act is to save labor for the survivors. Considering the fact that there is a 14 hour period of flight for bees in summer and that a bee is absent from the hive half

this time, and that a death rate of 2 per cent occurs within the hive, the chance of a bee dying outside the hive is about 120 times as great as that death shall occur inside the hive. If bees are given musty old combs which have been unused for two or three years they will clean them up in such a way that a lot of fine brown powdery substance is the by-product of the cleaning and is carried outside the hive. Every cell from which a bee hatches is given a thorough cleaning. The young bee leaves a cocoon infinitely thin in the cell. This is not ordinarily removed but the cell walls are worked over till they shine whether the next use of the cell may be for brood rearing or storage of honey and pollen.

5. Comb Builders.

The walls of honey comb cells are so thin that from 3,000 to 4,000 of them must be laid upon one another to make an inch in thickness, each wall so fragile as to crumble at the touch and yet so constructed that tons of honey stored in them are transported in safety thousands of miles. The secretion of wax having been completed by the bees, a single bee starts the first comb by attaching to the roof little masses of the plastic material into which the aforementioned wax scales have been converted by prolonged chewing. Other bees follow her example, and the process of scooping and thinning commence, the parts removed being always added to the edge of the work so that in the darkness of the hive, the honey comb grows miraculously downward and outward with mathematical precision. The bees start their work by making true hexagons. By far the larger portion of the cells in a hive will be found to measure about five to the inch. These are the worker cells. Another group will be found to measure about four to the inch. These are the drone cells and may be used for rearing brood or storing honey—seldom for pollen. If the cells were exact hexagons measuring five to the inch there would be exactly 28 13/15 cells to the square inch on one side of a comb. But there is not this exactness as will be shown by careful measurement, although the eye may detect no variation. Count the number of cells in a given length in a horizontal row of cells and then make the same count in one of the diagonal rows, and you will find they are not

precisely the same. Measure the cells in a number of combs built by different colonies, or even by the same colony and it will be found that they are by no means all of them five to the inch.

This refers to natural comb built by the bees without any comb foundation being supplied to them. Comb foundation is a sheet of bees wax with the bases of the cells impressed on each side and is generally made with cells of such size that worker comb built upon it contains about 27 cells to the square inch. The angle (Fig. I) at the bottom of the cell impression in the first foundation sheets turned out by the A. I. Root Co., of Medina, Ohio, did not suit the
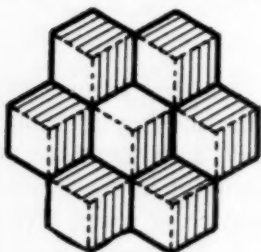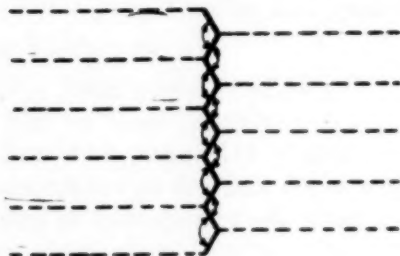
Fig. I   Fig. II

bees. The foundation mill had not been perfected. The manufacturers discovered the bees were changing the angle (Fig. II) to suit themselves. A change in the foundation making machinery was made to the apparent satisfaction of the bees. In the storeroom of the A. I. Root Co. may be seen many foundation sheets of both the correct make and the incorrect make on which the bees have worked two three, four, five, six and more days. In each case the bees are much further advanced on the combs made from the foundation whose angle was near enough perfection to suit the bees. The lost time on the incorrect sheet of foundation was consumed in correcting the angle to the bee's satisfaction.

Instead of lessening our admiration, the slight variation from exactness in the work of comb building when the bees are left free to their own course rather increases it, just as a piece of handmade work is often more admired than that which is machine made. The ingenuity displayed in adjusting the work to varying circumstances is something

far beyond machine like exactness. If you cut a few square inches of comb out of a frame of worker comb during the honey gathering season the chances are, ten to one, that the bees will fill the hole with drone cells. A few cells will be built that are neither drone cells nor worker cells, and these are called *accommodation* cells; but so skillfully are the adjustments made in passing from worker to drone cells that at a hasty glance one would likely say all were either worker or drone cells. The center of a cell on one side of a comb coincides with the edge of a cell on the other side. (Fig. III.)
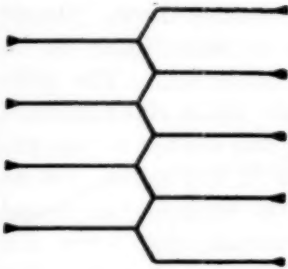
Fig III

Where worker cells end and drone cells begin is hard to see even though this perfect workmanship is the rule. No human skill can equal this. (Fig. IV.)
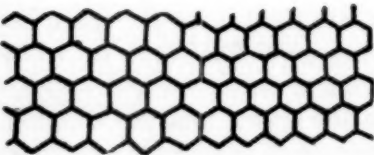
Fig. IV

In general comb is built so that an angle is at the top and bottom of each cell as in Fig. V; and this is believed to give greater strength than if the cells were built like Fig. VI.

Fig. V   Fig. VI

While the cell walls vary from 1/3000 to 1/4000 inch in thickness the base is thinner, being sometimes as thin as 1/5000 of an inch when first built. But as successive generations of young bees are reared in the cells, cocoons and secretions are left at the bottom of each and in time the base may become 1/8 of an inch thick. From this it happens that, although worker comb is 7/8 inch thick when first built, specimens of old comb may be found measuring an

inch in thickness since the bees draw out the cell walls at the mouth of the cell to balance the additions made at the bottom of the cell so as to maintain the same depth in an old cell as in a new one.

Fig. VII
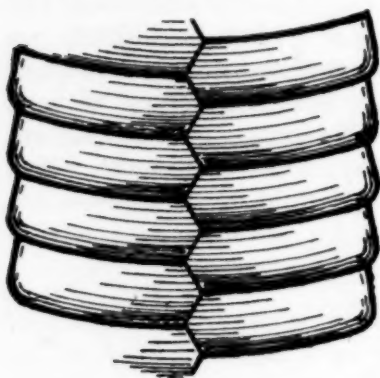
When however worker cells are used for storing honey, if there be room for sidewise expansion of the comb, the depth of the cells may be so increased that the comb is two or three inches thick. Drone comb is more likely to be thus built out. The cells of both kinds slant upward from the center to the exterior of the comb, yet so slightly that to the casual observer they appear entirely horizontal, yet when the comb is so greatly thickened for the storing of honey, the slant may be much increased, giving the cell a curved appearance. (Fig. VII.)

Cappings over honey are not air tight. An air space between the honey and the capping gives the comb its white appearance. Comb honey having a water soaked appearance has no air space between the honey and the capping. This kind of capping spoils the sale of otherwise fine comb honey. About 10 per cent of cappings over honey are absolutely impervious to air. The brood cell cappings appear to be very much more porous, evidently for the sake of allowing air for the larva inside. The brood cell cappings are made up of cocoon shreds, pollen, etc., with only enough wax to weld the whole together.

Drones are reared in cells of great variation in size. Honey is also stored in extra large sized cells. The outer end of very large cells is often turned up to prevent honey from running out of the uncapped cell. Capillary attraction is sufficient to hold honey in uncapped cells of worker size. Where drones are to be raised in very large cells the bees contract the mouth by a thick rim. Bees sometimes rear worker brood in drone comb, when com-

pelled to from want of room, and they always do it by contracting the mouth of the cells and leaving the young bee a rather large berth in which to grow and develop. Drones are sometimes reared in worker cells also, but they are so much cramped in growth that they seldom look like fully developed insects.

No one bee ever makes a complete cell. A bee comes to the building site with her supply of building wax. She seems to give the comb a little pinch with her mandibles. But she does not stay long. Another bee comes and gives the wax a little pinch or scraping or burnishing with her mandibles and hurries on; and the sum total of these maneuvers is that the comb seems to grow out of nothing. The comb is the product of the united efforts of many workers.

When the cells are built out only part way as illustrated (Fig. VIII) they are filled with honey and eggs and the length is increased later. They can probably take care of brood easier in shallow cells. The thick rim shown above is always left around the upper edge no matter what the depth so they have the material at hand to increase the depth at any time. This thick rim gives the bees a foothold, for the sides of the cell are so very thin that even the weight of a bee might break it down. The midrib of a natural comb becomes thicker as it approaches a line of support (Fig. IX) and tapers toward the bot-

Fig. VIII
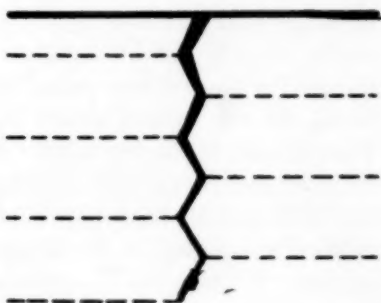
Fig. IX

tom. Why this is so is evident. That there should be this graduation from top to bottom is wonderful when we consider the large number of bees that have worked on it. After all of them have given it a twist and a pull it is likely to be just right for all practical uses of the bees and queen.

There is no such thing as artificial comb honey. This is one of the hardest truths to teach. The fancy white section in the store by its perfection lends itself to the spread of the untruth that comb honey is manufactured. The A. I. Root Co., Medina, Ohio, the world's largest manufacturers of bee supplies, made an offer of $1,000.00 for a single pound of artificially made comb honey. The $1,000.00 was never claimed.

6. Guarding The Hive.

Bees are thought to recognize members of their own colony by the odor of the hive or queen. A bee alighting on the running board, especially if nectar is scarce in the field, is often met by one to four guards who rush up to the newcomer. If her honey sac is full she is admitted though a stranger, but if it is empty she must possess the hive odor. Beekeepers often aid the guards of weak colonies by contracting the entrance to the hive. The guard is faithful unto death in defense of the colony.

7. Robbing.

With all their wonderful instincts bees apparently have no care for bees of another colony. Robbing another weaker colony is a very common occurrence. The first difficulty a robber encounters is the sentinels. If the colony is weak and careless and the robber slips by unobserved she is largely out of danger. There is a certain degree of danger in the robber going too quickly to the stores in the hives, so she loiters about as though very much at home. Finally she loads up with "stolen sweets." If finally discovered and recognized as a robber the first bee to encounter her will try to hold her till help arrives. Sometimes the robber will escape even though three or four bees have hold of her.

In case a robber escapes with a load to its home, it rushes in with a vigor and vehemence that can mean nothing else than "stolen sweets" to its sisters. Out it rushes again

with several comrades at its heels. The whole apiary is soon in an uproar. Robbing is the term used where bees steal jam, jellies, syrup, or honey from kitchens or warehouses. During these escapades they are very cross and will sting viciously without provocation. After the robbing is over the bees will often remain cross and irritable for several days.

8. Drifting.

Sometimes young bees not having thoroughly learned the location of their hive will *drift* to the hive having the largest number of bees flying before it and will go in as if it were their home. Even old bees when hives are brought out of the winter cellar will *drift* into the hive where bees are flying strongest. When bees *drift* into the wrong hive they are not treated as robbers. Robber bees in addition to having the wrong odor show by their actions that they are afraid of being seized. Their actions are different than those of the *drifting* bee in that they try to dodge the guards and enter by stealth.

9. Scouts.

A colony previous to swarming sends out scouts to find a new home. These scouts return to the hive and when the swarm issues, direct the journey. Bees have often been noticed going in and out of an empty hive. A few minutes or as the case may be a few days later a swarm comes and occupies the hive. One of the best scouting stories is as follows. Bees were observed at a hole in a hollow tree and a bee hunter cut the tree, expecting to find honey in it. There were no bees in it. While the hunter was still there puzzling over his mistake the roar of an approaching swarm was heard. Out of the blue sky they came, and the flying swarm hovered in space at the height of the opening in the tree trunk. The bees he had first seen were the house-hunting scouts who had returned to the hive and brought the swarm. Many cruel disappointments come to the scouts in these days of modern beekeeping, when queen clipping is practiced. The queen's wing is clipped to prevent her going with the swarm. Preparations for swarming go on in spite of the queen's inability to fly, and some fine day the swarm issues. The scouts start lead-

ing the way but soon all become aware that the queen is crawling along on the ground instead of flying with them. The disappointed swarm returns to the hive and so does the queen. They must now wait till a young queen is hatched who can fly away with them. Queen clipping gives the beekeeper at least two chances instead of one to capture his swarm.

10. Foragers.

Something has already been said about propolis, pollen and nectar gathering under the heading Transportation. A bee goes from flower to flower of the same variety, i. e., from cherry blossom to cherry blossom, never from cherry blossom to peach blossom. This insures cross pollination, i. e., the carrying of pollen from one blossom to another of the same variety. This results in more fruit than would be the case without the work of the bee. Sometimes the pollen pellet carried into the hive will be red or yellow or grayish, depending on the variety of flower the bee worked on during that particular trip.

In the absence of flowers honey bees will gather many other substances as substitutes for pollen. In early spring they may be seen on sawdust heaps collecting fine particles of wood which contain a little nitrogenous material. Occasionally they gather the spores of fungi which are very similar in composition to pollen grains. In Michigan they have been reported as gathering loads of fine black earth from swamps and have been known to collect even coal dust. In a cheese factory they were found packing into their pollen baskets the fine dust that had accumulated from handling cheese. Microscopic examination showed that this dust was cheese mites, so the bees were using living animals as food. In the springtime bees will use the flour or meal of rye, cottonseed, wheat, oats and peas. The above-mentioned materials are not continuously sought after by the bees. The materials sought for daily are *nectar* for honey, *pollen* for bee bread, *water* for brood-rearing and *propolis* for varnishing.

11. Reasons For The Success of The Colony.

1. *Division of labor* has just been discussed and anyone can see that much of the success of the bees is dependent on this factor.

2. Bees practice *standardization* in their products. A drop of nectar modified by one bee is no whit better or poorer than that modified by another. Bee bread for the young does not need to be advertised as our baby foods are by claiming superiority over other brands. Bees wax from one bee is no better building material than that from another. Standard production both as to quantity and quality is the rule.

3. There is a *proper balance in the production of goods*. Some days it may be easier for an individual bee to load up with water than with nectar. That does not mean that there will be a squabble over who is to carry water and who is to carry nectar. There will not be a lot of white-collared water carriers out of work that day. Bees do not oversupply themselves with some worthless product easy to produce.

4. There is no *profiteering at the expense of the colony*. The drone is starved out in the fall because the mating season is over and since he cannot help in the work of the hive, he is doomed to die.

5. *Small communities* of bees always fail. There is no place in their scheme of things for a successful small colony. 50,000 to 70,000 bees in a colony insures the best results.

6. In a *commercial crisis* we, in America, are "of all men most miserable." The queen bee immediately cuts down the birth rate in a poor season by laying very few eggs. Guards are posted against robbers, every bee does the very best she can, and general prosperity soon returns.

7. As described under "The Bee as a Craftsman" the worker bee *advertises* and tries to *sell* the idea of work when she does the "tailwagging dance," upon her return to the hive ladened with pollen or nectar. There is no such thing as "restriction of output" in the economy of the bee hive. Bees though they know nothing of economics are very successful because they practice many sound economic principles which you and I as citizens must practice if we are to be a success in life.

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FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE.

By Duane Roller,

The University of Oklahoma, Norman, Okla.

A history of psychology in America prior to the last fifty years would be as short as a book on snakes in Ireland since the time of St. Patrick. In so far as psychologists were concerned, America was then like heaven, for there was not a damned soul.—*J. McKeen Cattell in "Scientific Monthly," February, 1930.*

Music forces you to recognize that there is more beyond, to which we have lost the key. Its synthesis of higher mathematics (the most "mystic" science of all) and highest emotion is the closest approximation of reason with intuition that any art offers.—*Muriel Draper, "Music at Midnight."*

Error is worse than ignorance.—*Bailey.*

Those who want fewest things are nearest to the gods.— *Socrates.*

A man is down on what he is not up on.—*Elbert Hubbard.*

To make light of philosophy is to be a true philosopher.— *Pascal, "Thoughts."*

In order to reach the Truth, it is necessary, once in one's life, to put everything in doubt—so far as possible.— *Descartes.*

The greater intellect one has, the more originality one finds in men. Ordinary persons find no difference between men.—*Pascal, "Thoughts."*

Those who end by making all others think with them are usually those who began by daring to think for themselves. —*C. C. Colton.*

Not infrequently does it happen that the clearest conception of an idea is obtained by going back to the master mind that first felt the need for that idea, and invented a term to denote it.—*Henry Crew, "School Science and Mathematics," 9, 323 (1909).*

When Thales was asked what was difficult, he said, "To know one's self." And what was easy, "To advise another." —*Diogenes Laertius, "The Lives and Opinions of Eminent Philosophers."*

PHYSICS FOR THE PRE-DENTAL STUDENT.
BY E. W. SKINNER,

The School of Dentistry, Western Reserve University, Cleveland, O.

The problem of maintaining the interest and training of the "pre-student" who is looking forward to some professional or technical career, is one in which all teachers are more or less interested. Problems of this nature are of vital importance to the high school teacher, as he is often the one who helps to stimulate or direct the student toward the selection of his life work. It becomes the problem of the college teacher to "carry on" this interest, attempt to determine the aptitude of the student for the work for which he is preparing, and do all in his power to adequately train him in the fundamentals which he will need later on. Although the content of this paper will be directed mainly toward the teacher of physics, it is hoped that instructors in related fields will find it of interest.

Probably the student who offers the greatest difficulty to the teacher of physics is the pre-dental student. Most dental schools are now requiring college or high school physics for entrance. The pre-dental student, particularly in college, fails to see the relation between his chosen career and the study of physics. To him physics is merely an irksome requirement, to be passed over as quickly and as easily as possible. When he asks the instructor why physics is required for dentistry, he is apt to receive a more or less vague reply. Teachers of physics can always fall back on osmosis and capillary action, for example, when a similar question is asked by the pre-medical student, and if the pre-engineering students question the importance of physics, they find their instructor ready with a long oration, pointing out the very close relationship between physics and all branches of the engineering profession.

The thought that perhaps the lack of interest in physics too often prevalent among pre-dental students is partially due to a lack of appreciation of the problems of dentistry on the part of the instructor, has prompted the writing of this paper. The applications of physics to dentistry almost rival those in the engineering profession in number. It is estimated by prominent dentists that 90% of the service

rendered to the public by the dentist is of a mechanical
nature, and it may be added that this mechanical service
uses manifold basic physical principles, the great majority
of which are of an elementary nature. A few of the im-
portant applications of physics to dentistry will be dis-
cussed, in the hope that such material may prove helpful to
those teachers who instruct pre-dental students by giving
them an idea as to what portions of the course are of ap-
plied importance to their students, and the use to be made
of the material later by the student.

A very important application of physics to mechanical
dentistry is the laws of force, static in particular, and
dynamic to a less degree. A knowledge of force application,
resolution, and elementary vector algebra finds almost con-
stant use. In many ways mechanical dentistry parallels
structural engineering in the knowledge which should be
in the possession of the dental technologist. For example
the dentist constructs bridges, both ordinary abutment and
cantilever types, the stresses of which are not at all unlike
the fundamental stresses of similar bridge and viaduct
structures. A cantilever bridge in the mouth is given an
abutment on one tooth by means of a crown for example,
and "swings" toward the tooth next adjacent to the missing
one. The proper diagnosis of the type of bridge to use
(i. e. cantilever or ordinary abutment) depends for the
most part upon a correct analysis of the stresses at the
position where the restoration is to be made.

A layman does not realize the magnitude of the stresses
brought about by the "bite" of the human jaw. According
to tests made by Dr. Black,[1] the biting strength of the first
molars varies from one hundred fifty to two hundred fifty
pounds, depending upon the individual. He estimates that
some cases may show as high as three hundred pounds.
The argument for force analysis is evident.

The selection of materials to be used in restorations is
made in part by .considering the direction and magnitude
of the forces which will be present in the finished case.
In placing gold foil fillings, the stresses caused by the oper-
ator in driving the metal into the cavity must have a definite
direction and magnitude to completely wedge and weld the

[1]Black, Operative Dentistry, Vol. II, p. 245 (Medico-Dental Publishing Company, Chicago).

metal so as to give complete and permanent retention. Denture (false teeth) construction requires careful and thorough analysis of the forces present for lasting results. Space does not permit explanation of the physical applications to the complicated structures involved.

Not only the directions of the forces must be considered, but also the possibility of torques being produced. The restoration may be able to withstand the crushing forces, but possibilities of the rotation of the filling, inlay, or denture out of position must be avoided. It is readily realized that the resultant stresses in such torques may be enormous, if for example the biting force happens to be applied on the long arm, and the arm of the resisting force being very short as is often the case.

The mandible is an interesting physical problem as regards motion and resulting stresses in mastication. It presents a motion similar to a horseshoe, hinged at the two ends, and operated as a lever of the third class. In order to more closely approximate a mandibular motion, the system must be further complicated by allowing lateral motion of the hinges or fulcrums together or separately, in addition to the vertical motion. It is the forces resulting from such a system with which the dentist must deal. Obviously these factors become enormously important in denture construction.

As a specific illustration of the application of force and lever laws to dental restorations, a typical case will be considered. Assume that decay exists in an upper left central incisor tooth on the left proximal edge, and that the operator is compelled to cut away the tooth structure on this edge from slightly below the gum line to and including a portion of the incisal edge. Owing to the position of the cavity between the teeth, a gold foil filling is rendered very difficult, and hence a gold inlay is to be used. An analysis of the forces and moments brought to play largely determines the exact nature of the cavity preparation. The forces involved can be resolved into three principal components: (1) a force directed upward on the tooth toward the gum, (2) a lateral force more or less perpendicular to (1), and (3) a force acting toward the lips from within the mouth, perpendicularly to (1) and (2).

The displacement of the inlay toward the gum by (1) is resisted by cutting a supporting shelf or ledge at the base of the cavity. The tendency of force (3) is to dislodge the inlay in a labial or anterior direction. This is prevented by extending the inlay slightly on the lingual side of the tooth, which of course means that the cavity preparation must be accommodated to receive this extension. This provides what might be described as a "backing" for the inlay. Force (2), or what is more probable, a resultant of (1) and (2) together, applied at the incisal edge or tip of the inlay, produces a torque, the direction of the force making an acute angle to a plane passing through the tips of the upper teeth thus making the base of the inlay the center of rotation, or fulcrum. Apparently any retention to resist such a torque must be strong since the system is readily recognized as a lever of the second class. One interesting method of preventing such a rotation is to extend a "T" shaped tongue from the lingual surface of the inlay, perpendicularly to the proximal edge of the tooth, thus forming a male or tenon of a joint with a female part previously prepared in the tooth structure. Technically this restoration carries the descriptive name "lingual dovetail inlay," the aptness of the name being self-evident from the description. A restoration of this type is carried out very successfully, the entire inlay not extending more than one-third the width of the tooth.

It is evident that no resistance has been provided for stresses directed against the inlay into the mouth and hence the inlay may be displaced if a force is exerted in this direction. Ordinarily such forces are not present in an upper first incisor, but the diagnostician must be able to recognize the exceptions. Obviously such an inlay on a lower incisor would be futile, because of the force exerted by the upper teeth on the lowers when the mouth is closed. A good illustration of a case which would be exceptional is one in which the lower teeth are in protrusion or labial relation to the upper teeth. Such a functional position tends to bring unnatural forces into play directed lingually (inward) on the corresponding opposing teeth and would contraindicate the use of this type of inlay.

These are only a few of the factors which must be taken

into consideration by the dentist before even determining the type of restoration to be used in a given case. This is only one example. There are many different types of restorations, all of which call for varied analyses and constructions, but all requiring technical considerations, by far the greater part of which are the application of simple principles of physics contained in any course in college physics worthy of the name.

Another very important application of physics to dentistry is the material taken up in textbooks of physics under the heading of properties of matter. A considerable amount of the mechanical work of the dentist deals with metal working and hence an understanding of the physical properties involved and their significance is of importance. Cohesion, for example, is of importance in many procedures, notably in welding and casting techniques. Adhesion obviously has application in soldering and similar technique. Dentures are held in position in the mouth partly by adhesion between the vulcanite and the moist membranes. The use of dental cements also furnishes examples of adhesive phenomena.

Hardness, ductility, malleability and the laws of elasticity play extremely important roles in swaging and other forms of cold working, annealing, etc., and also are important in their relation to the stress properties of the metals. Surface tension and related phenomena find application in the flow of solder, and the many physiological phenomena with which the dentist must be familiar. Diffusion phenomena occur in soldering, and alloy preparations, particularly in annealing or heat treating the latter. An elementary knowledge of crystal structure is of great help in this connection.

Friction plays an important role in the retention of many restorations. Abrasives are used quite extensively, in connection with which the laws of friction are also helpful.

The casting of gold crowns and inlays is probably receiving as much attention in dental research at the present time as any other phase of the work. In brief, the technique consists of taking a wax model of the piece to be cast. This model is then embedded in investment, which is a mixture of plaster of Paris and silica. After the investment becomes hard, the wax is eliminated by burning or boiling.

This leaves a mold, into which the molten gold is poured. Obviously the gold casting must be identical with the wax pattern, a result which is difficult to realize, since gold alloy contracts approximately 1.25%[2] upon solidifying.

This contraction is offset by thermally expanding the wax pattern while the investment is setting, and then the investment at a still higher temperature before pouring the gold. Such a technique should require accurate knowledge of the expansion coefficients involved and their significance. Many interesting studies are being carried on at the present time in reference to the expansion phenomena of dental materials.

To understand thermal expansion, one should also have a knowledge of the physical significance of temperature. The Fahrenheit and Centigrade scales are used interchangeably in dentistry, hence a knowledge of both, and how to change from one to the other is important. Thermometry and pyrometry also find application in casting. Dental ceramics particularly often calls for temperatures in the neighborhood of twenty-five hundred degrees Fahrenheit (temperature for the "final glaze" in some dental porcelains).

The thermal conductivity of many materials used in mouth operations is important. For example, one objection to vulcanite dentures is the low heat conductivity of the vulcanite which is not conducive to healthy gum and palate tissue. Also if the dental pulp is closely approached in a cavity preparation, it must be heat insulated if the filling or inlay is a good conductor of heat. Thermal convection and radiation is of importance in soldering, for example. Particularly beginning students of dentistry do not understand that heat applied to one part of a piece of work will not heat up another portion enough to make solder flow, or vice versa, that heating one joint, is apt to make another adjacent joint come unfastened. An appreciation of the heat transference and specific heat of the metal would save considerable time and grief.

Fusion phenomena find application in heating of metals and alloys. Not only are crystalline substances subjected to heat treatment but also non-crystalline materials. The dentist as well as the physicists and chemists will welcome

[2]Coleman: Physical Properties of Dental Materials, Bureau of Standards Research Paper No. 32; Bureau of Standards Journal of Research, December, 1928.

more research in the physical properties of amorphous substances. In this connection cooling curves of pure metals and alloys might be mentioned as desirable for study from the aspect of physics. A knowledge of the laws of thermodynamics is, of course, desirable in connection with cooling phenomena as well as the laws of cooling.

When extraction of all the teeth becomes necessary, a substitute artificial full denture is made. Among other complex factors for consideration is that of reproducing a condition which does not hinder speech. A knowledge of sound phenomena, particularly relating to the physics of phonetics is desirable for this work.

Roentgenology plays a very important part in modern dental diagnosis. The dentist should be familiar with the elementary scientific principles involved, hence the fundamental laws of electricity become of importance. A few specific items which find use in x-ray technique are Ohm's law, simple alternating current theory, transformer theory, electrical heating effects, electron emission, Edison effect, electrical instrument principle and design, and electrostatics. Many of the electrical laws will of course be found valuable in the handling of other electrical equipment. In connection with pyrometry, obviously a knowledge of potential difference is important, particularly in reference to thermo-electricity. Contact potential difference and the electromotive series find an important application in the selection of filling materials. According to Dr. Hodgen' "——, the dentist should give some thought to the selection of metals to be placed in the mouth in restorative work since the presence of unnoticeable stray electrical currents may be detrimental to the permanence of tooth structure immediately adjacent to metal fillings or appliances."

The phenomena usually included in physics textbooks under the heading of light, find application in Roentgenology and light therapy, the latter being a more or less new idea in dentistry. A study of the entire spectrum is desirable in this connection, together with a certain amount of wave phenomena. The dental student finds much use for a microscope, and a study of optics is necessary for intelligent handling and manipulation.

'Hodgen: A Practical Dental Metallurgy (Sixth Edition) p. 43.

Color phenomena plays an important role in the selection and coloring of porcelain teeth, particularly in the matching of teeth. A discussion of the selection and coloring of porcelain restorations is developed in a paper by Dr. Vehe[4] in which he gives a complete discussion of color phenomena as found in physics textbooks and emphasizes its importance as applied to dental porcelain work.

It will be readily recognized by the teacher of physics that the above material has been presented in the order given in many physics textbooks. It should be emphasized that only a few principle applications have been presented. It is safe to say that there is not a single item covered in the standard courses in either college or high school physics, but which is valuable to the pre-dental student as a matter of general knowledge, if not as a direct application. Dentistry as a science is progressing rapidly and is constantly demanding more scientific background. Hence a training for the future, as well as the present, is necessary.

[4]Vehe: Porcelain Veneer Crown Technique, J. A. D. A., 17: 12 pp. 2167-2176 (December, 1930).

BIRDS WILL SOON BE HERE—BUILD THEIR HOMES NOW.

How discarded packing boxes may be converted into many different types of attractive bird houses is demonstrated by the National Committee on Wood Utilization of the Department of Commerce, in its recent publication entitled "You Can Make It for Camp and Cottage," the second of a series of booklets designed to bring about closer and more economical use of second hand wooden containers and odd pieces of lumber.

It is pointed out that with the approach of spring, now is the proper time to prepare accommodations for the feathered visitors. The average boy, with a few simple tools found in every home, a can of paint and a brush, and guided by plans shown in the booklet, can prepare homes for all common species of birds.

"You Can Make It for Camp and Cottage" contains more than 100 plans and designs. Everything from camp stools to fishing tackle boxes can be made from the suggestions and working plans set out in the booklet. Desks, tabourets, beach sandals, folding tables, chairs and numerous other articles of utility and convenience are included.

According to the Committee, camp directors, schools, civic organizations, playground associations, and boys' and girls' clubs throughout the country have displayed considerable interest in the booklet and are cooperating in its distribution.

"You Can Make It for Camp and Cottage" may be obtained for ten cents a copy from the Superintendent of Documents, Government Printing Office, Washington, D. C., or from District Offices of the Department of Commerce, located in principal cities of the country.

FOUR UNITS TO ILLUSTRATE MOTIVATION IN THE
TEACHING OF GEOGRAPHY: PART IV.

By Alice J. Hahn,
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The last unit which I chose to present is taken from that on *Temperature*. There are, of course, several factors which help to determine the temperature of a region, among which *distance from equator, altitude,* and *winds and ocean currents* are all very important. Each of these is taken up in turn, the first one to be studied being that of *distance from equator*. We all know that temperatures do not vary consistently as does the sun or else every place on the same line of latitude would have exactly the same average temperature, which is not so. But the *position* of the sun in the sky for different places in the same latitude does not vary, i. e. the sun is exactly as high in the sky at noon in Chicago as it is at any other place having the same latitude, when it is noon there. Since the position of the sun in the sky and the length of time it shines play a very important part in determining the temperature of a certain area, the children are taught to draw what we call *sun-shadows* for every line of latitude 10 degrees apart. They are also given tables which will help them in determining the length of time that the sun shines between sunrise and sunset. The drawings which are made show not only the position of the sun in the sky at noon, but also the length of the shadow cast. In order to make sure that the children understand these, they are given help in working out several together, the directions for which are given in the unit. Let us read the instructions for the first one together:

(1) The Equator. Draw a line around your protractor making a semi-circle to represent the heavens. Let the object which is to cast the shadow be ¼ inch high, and place it directly below the zenith. Now suppose that you are on the Equator on March 21st. Where is the sun shining down directly at noon on that date? (The answer, of course, is on the Equator.) Where then would you look to see the sun? (We see that it would be directly overhead.) Locate it with a dot on the semi-circle. Would there be any shadow? (And, of course, there would not.) (2) Now suppose that the date is June 21st, and that you are on the

Equator.   Where is the sun shining down directly at noon on that date?   (We find that it is on the line of latitude 23½ degrees North of the Equator.)   In what direction then would you look to see it?   (The direction is, of course, North.)   How many degrees away from the zenith?   (23½ degrees.)   Locate it with a dot on the semi-circle.   With your ruler connect up the dot representing the sun and the top of the line representing the object, and draw the shadow which would be cast by it.   (3) Do you see that the shadow for Dec. 22, although of the same length as on June 21st, would be cast in the opposite direction?   Why?

Going on to parts *d* and *e*, the children are referred to the readings at the beginning of the unit, and write out reports under these headings to be handed in later.

In contrast to the sun-shadows at the Equator, we next choose a place 70 degrees North of the equator and work out the sun-shadows in a similar way.   We find that on March 21st, the sun at noon is shining down directly on the equator, and that we should see the sun as many degrees away from the zenith as we are degrees away from the equator, or 70 degrees to the South from directly overhead.   The height of the sun then would be 20 degrees above the Southern horizon at noon, and the length of the shadow would be found as before.

On June 21st when the sun is shining down directly at 23½ degrees North of the equator at noon the position of the sun for us would be 70 degrees minus 23½ degrees or 46½ degrees away from the zenith to the South.   The shadows you see would be considerably shorter than on March 21st since the sun would be higher in the sky, and its rays more direct.   The position of the sun on September 22 at noon would be exactly the same as on March 21.   But let us see what would happen on December 22. The sun then at noon would be shining directly above the line of latitude 23½ degrees South of the equator so that in 70 degrees North latitude, its position would be 70 degrees plus 23½ degrees or 93½ degrees South of the zenith.   This is, of course, 3½ degrees below the horizon, so that the sun on that day would not be visible at any time, and naturally there would be no shadow.   The children are usually much surprised to find this so, and it delights them to think that

they have discovered something for themselves. Having worked out the sun-shadows and having found, from their tables, the length of the day, they again come back to parts *d* and *e*, answering the same questions for this latitude as they did for latitude 0 degrees at the Equator. That is, they relate these facts back to the types of agriculture, vegetation, types of animals, and the work and civilization of man, in so far as that is possible, remembering, of course, always that altitude, and winds and ocean currents play a part in determining temperature as well as does the distance from the equator.

Reading for Unit VII

I. Temperature as affected by:
  A. Distance from Equator

1. New Physical Geog.	(Tarr and von Engeln) pp. 453-455; 401-404; 405-406; 409-411
2. Climate	(Ward) Chap. I
3. Climate of the U. S.	(Ward) pp. 11-23
4. H. S. Geog.	(Dryer) pp. 172-181
5. Intro. to Econ. Geog.	(Jones and Whittlesey) pp. 170-171
6. Modern Geog.	(Salisbury, Barrows and Tower) pp. 34-40

Unit VII

Probably the one thing or element of our natural environment to which we must adjust ourselves most often is *climate*, or the conditions of the atmosphere, including *temperature, rainfall, pressure* and *winds*, which vary not only from place to place at the same time, but often also at the same place from time to time. We shall study each one separately, trying to explain the reason for the distribution and variability so far as that is possible, and then relate these conditions back to the human activities and adjustments.

I. Temperature as affected by:
  a. Distance from Equator

Temperature does not vary consistently as does the sun because of other factors which enter in to change it. These we shall study later. But the position of the sun in the sky does play a very important part in determining the temperature of a certain area, the reason for which you will find in your lesson. We shall, therefore, draw sun shadows which will show you the position of the sun in the sky at noon. We shall work a
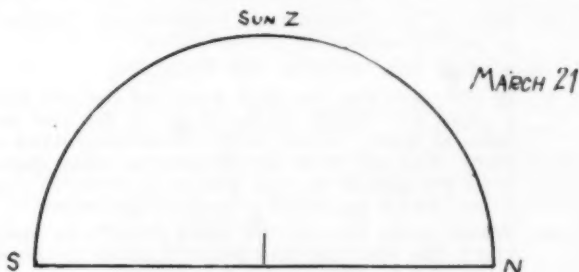
few of these out together first. Then you will work others
out for yourself later.

1. The Equator

Draw a line around your protractor making a semicircle
to represent the heavens. Let the object which is to cast
the shadow be ¼ inch high, and place it directly below
the Zenith. Now suppose that you are on the Equator on
March 21st. Where is the sun shining down directly on
that date? Where then would you look to see the sun?
Locate it with a dot on the semicircle. Would there be
any shadow?

b. Now suppose that the date is June 21st, and that you
are on the Equator. Where is the sun shining down
directly at noon on that date? In what direction then
would you look to see it? How many degrees away from
the zenith? Locate it with a dot on the semicircle.
With your ruler connect up the dot representing the
sun and the top of the line representing the object, and
draw the shadow which would be cast by it.
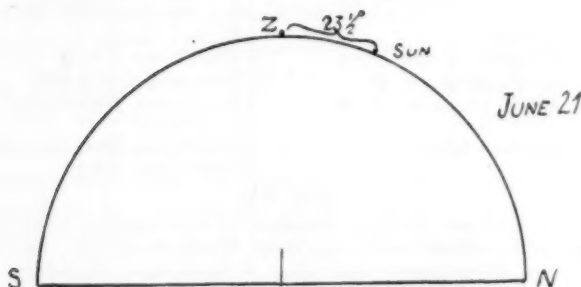
c. Do you see that the shadow for Dec. 22nd, although of
the same length as on June 21st, would be cast in the
opposite direction? Why?

d. Do you believe that so far as the change in position of
the sun is concerned that the temperature at the equator
would change much from time to time? How is this
related to
    (1) Type of agriculture
    (2) Vegetation
    (3) Type of animals
    (4) Man
        (a) His work
        (b) His civilization

e. Make a list of important places where the sun shadows
as approximately as drawn above.

2. At a place 70° North of the Equator

a. In the same way we shall work out the sun shadows for
a place 70° North of the Equator for the same three
dates at noon. Where is the sun shining down on March
21st? You will then see the sun as many degrees away
from the Zenith as you are away from this particular
point. Draw the shadow as you did before.

b. Where is the sun shining down directly at noon on June
21st? Do you see that your distance in degrees from
this point is 70°—23½° or 46½°?

MARCH 21

JUNE 21
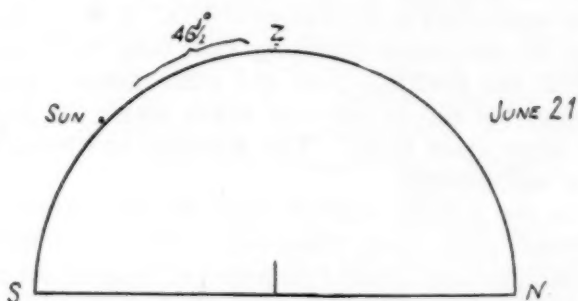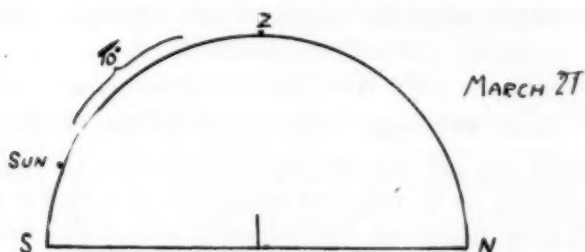
c. Where is the sun shining down directly at noon on Dec.
    22? The distance now will be 70°—23½°. Why? Will
    there be any shadow on this day? Note that the sun is
    below the horizon at noon.

DEC 22
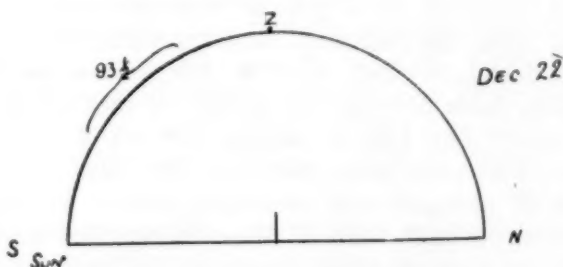
d. Answer the same question as in 1 *d* above.

e. Same as 1 *e* above.

3. You will now draw shadow pictures for each of the lati-
    tudes 10° apart, both North and South of the equator for
    March 21st, June 22nd, and Dec. 21st.

    a. Be able to answer the same questions for each as in
        1 *d* above.

    b. Make a list of all important places in each latitude
        (or approximately so), where these conditions are found.

    c. Make a special study of wheat farming in Argentina and
        the U. S. Note the reverse of conditions and explain
        this situation. Study the advantages and disadvantages
        of such a situation in:

        (1) Exchange of products

        (2) Migration of man

BACKGROUND AND FOREGROUND OF GENERAL SCIENCE.
No. XVII. MACHINES.
By WM. T. SKILLING,

State Teachers' College, San Diego, Calif.

Whether we are considering the machine in relation to social science or to physical science it is a factor too important to be neglected. On the social side it has made possible the almost infinite variety and abundance of what we term necessities and luxuries of life. It has taken away much of the household drudgery that used to be necessary to provide our clothing, food and other needs. But it has often gone too far in this and taken away the possibility of any labor from many. The machine has brought both blessing and disaster.

But in the general science class we are concerned with the physical facts about machinery. There are many general principles and other fundamental facts about machinery simple enough and important enough to be presented in a beginning course in science.

There is every reason why boys should become well grounded in the rudiments of this subject. The argument for girls is a little more remote, possessing some strength perhaps, from the fact that such knowledge is cultural in a society in which every one who drives an automobile has a traveling laboratory in the subject of mechanics.

Not every boy can or should become a white collar worker. For very large numbers the future holds more promise of pleasure and economic success in productive mechanical pursuits than in the over crowded professions. The schools have done too much to lead boys who would, with proper training, make good mechanics, into lives for which they are not fitted. The science class can scarcely make a mistake by striving to make tools look attractive. What normal boy (or man) does not receive something of a thrill by standing before the show window of a hardware store with its attractive array of shining tools? A study of machines should intensify the thrill.

There are many methods both logical and psychological of beginning almost any subject, but, as a suggestion, we might mention a discussion of what constitutes a machine as a good beginning here. A machine may do any one of

at least three things. It may give greater speed of motion
than we could achieve without it, as for instance the egg
beater as compared to a spoon. It may give more force
than could be exerted with the bare hands, as in the lever
used in lifting heavy stones in a quarry. It may simply
change the direction of motion without affecting either the
force exerted or the speed as when the old oaken bucket is
drawn up by a rope running over a wheel above our heads.

Pupils should understand that as the word "machine"
or machinery is usually employed it refers to some device
such, for example, as the sewing machine, in which there
are a number of the so called "simple machines" working
together to bring about the desired results. In either sense
of the word a machine is something that transmits energy
to a thing upon which work is to be done.

Of course the words energy and work, and force as well,
need to be explained. For the purpose of making plain
these and other terms likely to come up, such as foot pound
transformation of energy, etc., it is far better to adduce
numerous illustrations than to teach bare definitions.

The simple machines, which are the elements out of
which all machinery is made, should be illustrated by draw-
ings, but much more important yet, should be demonstrated
by actual or improvised examples of each. Since the chief
use of all these simple machines is to give us greater force
or speed everyone should be able to find how much force or
speed is given by each machine, that is, to find its "advan-
tage."

One of the important lessons for the beginner to learn
is that no machine can give both more force and more speed
at the same time. Going a step further in this direction it
should be known that if force is gained exactly the same
amount of speed is lost, or if speed is gained just that much
force is lost.

Many simple problems can be worked by young students
if they are first taught how to find the "advantage" of each
machine. This is simply done for among the eight princi-
pal types of machines the advantage of seven of them is
found by *dividing* something by something else, as follows:

(1)   Lever: Long arm ÷ short arm = advantage.

(2)   Wedge: Length ÷ thickness = advantage.

(3)   Inclined plane: Length ÷ height = advantage.

(4)   Crank and Axle: Length of crank ÷ radius of
axle = advantage.

(5)   Gears: Number of cogs on larger wheel ÷ number
on small wheel = advantage.

(6)   Belt wheels: Diameter of large wheel ÷ diameter
of small wheel = advantage.

(7)   Screw: Distance the force moves in making one
turn ÷ distance between threads = advantage.

(8)   Pulleys: The number of supporting cords = advantage.

Common sense, only, is necessary to determine whether
the advantage as found above is one of speed or force.
Whichever it is there is a like disadvantage of the other.

Very many common examples of simple machines will
suggest themselves as being suitable to use for purpose of
demonstration.   A meter stick or a yard stick makes a good
lever.   Sawing diagonally through a block makes a wedge.
The wedge will serve as an inclined plane, or a board raised
at one end will do.   A crank and axle can be made from a
large spool.   An egg beater has gears.   The chain of a bi-
cycle is virtually a belt.   (The teeth are to keep it from slip-
ping.)   A vise serves the purpose of a screw, and lastly,
metal pulleys may be purchased at the ten cent store.

As to problems in the use of simple machines of the vari-
ous sorts there is almost nothing to them after the advan-
tage of the machine is found.   They are all worked alike
regardless of the machine.   For example if we want to find
what resistance can be overcome by a force of ten pounds
applied to a machine whose advantage is five, the answer
must be either 50 or 2 depending on whether the force is
applied so as to gain force or speed.   For all machines the
answer will be the same.

Such problems offer a good opportunity to teach pupils
to think rather than to blindly follow a rule.   For example,
if in the above problem the force is applied to the long arm
of a lever the weight lifted would be fifty pounds.   But if
the force acts on the short arm ordinary intelligence, if
exercised, would indicate that two is the answer.

Such grouping of many apparently different problems
under one or a few principles could oftener be done in

science and mathematics, and would simplify and add interest to the work. We should give more attention than we do to classifying separate facts. Education is knowledge systemized.

Friction is entirely overlooked in giving the methods by which the advantage of machines is found. In some machines, as the lever, friction is unimportant, in others, as the screw, it constitutes a large part of the resistance to be overcome. An exhibit of a few samples of the ordinary lubricants for different kinds of machinery will help to bring this phase of the topic into the realm of reality. Nearly all lubricating oils and greases are made by the distillation of petroleum. Sometimes graphite is mixed with the grease. Notice the feeling of a sample of graphite.

To show the effect of ball bearings lay several of the balls on a hard floor and step on them. The foot slips more easily than if in contact with the floor.

Roller bearings take the place of ball bearings in very heavy machinery. The rollers have more surface to support pressure. They are beginning to be used in railway cars. Quite recently a large locomotive engine has been made with roller bearings and is designed to go at a speed of 85 miles an hour. It is being lent to various railroad companies so that it may be tried out under as many different conditions as possible of passenger and freight traffic.

VISUAL EDUCATION.

"Seeing is believing." Very often it is also understanding and remembering. Many new ways of learning by seeing have been devised. The projection lantern has long been used and its importance increases with each year. New features are being added to make its use more effective and more convenient. A new combination projector has recently been perfected by the E. Leitz Company. It offers greater brilliancy, increased flatness of field and sharpness of screen image than prevails with any former models. It is equipped with four parabolic mirrors tending to concentrate the rays so that maximum efficiency is obtained. The mirrors, furthermore, cast the light in an evenly distributed manner eliminating the possibility of shadow, whereas a well equipped ventilator-cooling system continuously blows cool air upon the specimen, thus protecting same from any possible damage. The convenient manner of placing the specimen into position and the ease and convenience of changing from one mode of projection to another is very interesting. Furthermore, means are provided for micro-projection, for projection of film slides and film made with the "Leica" Camera. An attachment for demontration of physical phenomena can likewise be supplied. Descriptive pamphlet No. 1177 may be obtained by writing to E. Leitz, Inc., 60 E. 10th Street, New York, N. Y.

POINT-COLLEGE.

By Helen M. Schlauch,

Hunter College, New York City.

A Mathematical-Collegiate farce concerning Analytics College in which the student body is composed of animated points.

Cast of Characters:

(0,0)_____a freshman

(∞)_____a junior, advisor to (0,0)

(1,5)
(a,b)
(−4,−9) } _____freshmen
(−4,−8)

(−1,−3), president
(−2,−6)
(−3,−9) } _____members of the sorority: $3\alpha - \beta$
(−4,−12)

(2,−2), president
(3,−9/2)
(−2,−2) } _____members of the sorority: $\alpha^2 + 2\beta$
(−1,−1/2)
(1,−1/2)

Scene 1:

The plane of Analytics College. A large cardboard plane, marked as graph paper forms the background.

[*Enter* (0,0) *carrying a suitcase. She puts the suitcase down and looks about.*]

(0,0):   (*sentimentally.*) So this is college at last! Just as I hoped it would be. I wonder what that tall building is on the hill? I don't suppose it can be the place where I'm supposed to live . . . (*looks bewildered*). I wonder where that dormitory is! Oh, I wish I knew where to go . . . everyone else seems so much at home, but I . . . I'm all alone . . . (*She is on the verge of tears*)

[*Enter* (−1,−3), (2,−2), (−2,−6) *talking and laughing.*]

(−1,−3): Say (−2,−6), I hear you're trying to gain weight.

(−2,−6): Yes, I want to wear the new styles . . . but it doesn't do any good.

(−1,−3): Well, what do you expect? You haven't any dimension.

$(2,-2)$:   Taking thought can't change that . . . even the
               Profs. who study us little points won't help us.

$(-1,-3)$:   I guess we ought to be glad we exist, even if it is
               only in their minds.

[*Exeunt. As they passed,* (0,0) *made a feeble attempt to attract their
attention, then retreated.*]

(0,0):   If I ask them where to go they'll know I'm green
               . . . what shall I do? (*sits on suitcase*) I simply
               must ask the next per . . .

[*Enter* (∞).]

(0,0):   Pardon me . . . could you tell me if that's the
               Freshman Dormitory? (*points up on the hill*)

$(\infty$):   The frosh dorm? I should say not! That's the
               lib.

(0,0):   The lib?

$(\infty$):   Oh . . . the library, where the math. people study
               us, you know. But you want the dorm, don't
               you?

(0,0):   Please. I want to know where I belong here. . .

$(\infty$):   By the way, are you (0,0)?

(0,0):   Yes, how did you know?

$(\infty$):   I've been looking all over the plane for you . . .
               I'm your Junior adviser.

(0,0):   Oh, I remember . . . you wrote to me about college
               . . . you're (∞), aren't you?

$(\infty$):   Yes, that's right.

(0,0):   You must think me stupid, but I don't understand
               the college terms yet. What's the plane?

$(\infty$):   Oh, it's all this (*points to the background*) . . . the
               Analytics campus. And that's where you're to
               live. (*Points to the origin.*) Don't worry about
               being stupid . . . all freshmen are like that, but
               they learn. It's my job to tell you all about
               college. Let's see . . . you'll want to find your
               room, register, see the dean, and get ready for the
               inter-sorority rush party tonight. . .

(0,0):   (*excited*) Tonight! Do they begin so soon?

$(\infty$):   Yes indeed. We can't give the freshmen time to feel
               homesick, so we give them parties nearly every
               night.

(0,0):   (*indignantly*) Homesick? We're not babies.

(∞):   Well, maybe not.   Anyway you'll be rushed all week . . . that is, if you're interested in sororities.

(0,0):   Oh, I am! (*timidly*) Would you mind telling me which one you belong to?

(∞):   I? I don't belong to any. (*bitterly*) In fact, I don't seem to belong anywhere.   No one seems to want to admit my existence.   I suppose I must be rather queer.

(0,0):   I don't think so!   Do you know, I think I've heard of you.

(∞):   Really?   When I don't exist?

(0,0):   Yes, there's a new college I've just heard about, called Projective College.   They call you the point-at-infinity there, and they think you're very interesting.

(∞):   That's marvelous!   I'll transfer there next week . . . but, meanwhile, I'm supposed to help you. You say you'd like to join a sorority?

(0,0):   Oh, yes.   Do you think I'll make one?

(∞):   (*after looking carefully at* (0,0)).   You mustn't expect too much because there are only two sororities here: $3\alpha - \beta$ and $\alpha^2 + 2\beta$.   They're both very exclusive . . . most of the points of the plane never get into them, because they have such difficult conditions to satisfy.

(0,0):   Which one is better?

(∞):   They're very different, and you'll never have to decide between them because they've never chosen the same girl.

(0,0):   Never?

(∞):   Hardly ever.   There's a tradition that one remarkable point joined them both.   Her name was $(-6, -18)$.   But since her time no one ever has.

(0,0):   Well, I hope I make one!

(∞):   Don't expect too much!

[*Enter* (1,5), (a, b), (4,9) *and* (−4, −8)]

All four: (*to* (∞))   Can you tell us where the dean's office is?

(∞):   Yes, I think you frosh had all better go to her now before the office closes.   (*to* (0,0))   I'll show you your room after that. You wait here, and I'll see if the dean is in.

(*Exit* (∞)]

(1,5): You're a freshman too, aren't you? What's your name?

(0,0): (0,0).

(a,b): Say, did you know about the rush party tonight?

(0,0): Yes, are you going?

(a,b): And how! With my position on the plane, they'll have to bid me.

(0,0): What's your position?

(a,b): Oh, I'm at home everywhere on this plane . . . they all know me!

$(-4,-8)$: *(to (0,0))* What is your position?

(0,0): *(points to the origin)* Over there.

(a,b): There?? Why, no one of any account lives over there! . . . no one that is anything. And you expect to make a sorority!

(∞): *(comes in and beckons to them)* Come on, now . . . the dean is ready to see you.

(Exeunt all but (0,0)]

(0,0): *(goes over to get her suitcase)* Everyone seems to think I'm of no account. These other girls are so sure of themselves . . . oh, I know I won't make a sorority!

    (Follows the others out.)

<p style="text-align:center">SCENE 2:</p>

Two weeks later. The background is the same, but there is a table before the plane, and several chairs are grouped about it. On the table stands a cardboard placard reading: $\alpha^2 + 2\beta = 0$.

[Enter $(1,-1/2)$, $(2,-2)$, $(3,-9/2)$, $(-2,-2)$, $(-1,-1/2)$. $(2,-2)$ *takes the place at the table. The others sit on the chairs.]*

$(2,-2)$: *(Raps for order)* The meeting will come to order! Sorores, we are gathered here to consider the election of new members, and since our dual pledging with $3\alpha - \beta$ takes place here in a short time, we must be quick in electing. When I read a name, give your opinion in turn. Ready?

$(-1,-1/2)$: Shoot. *(She is leaning back lazily in her chair.)*

$(2,-2)$: First, (2,7). What have you to say $(1,-1/2)$?

$(1,-1/2)$: Don't like her.

$(2,-2)$: Would you blackball her?

$(1,-1/2)$: Sure.

$(2,-2)$: Then you must give a reason.

$(1,-1/2)$: Don't like her.

$(-1,-1/2)$: (*jumps up excitedly*) Well, I don't think that's fair! Just because one person doesn't like her. . . .

$(1,-1/2)$: Yeah, but that one person has good judgment.

$(-1,-1/2)$: Says you!

$(2,-2)$: Order! Shall we apply the test?

$(-1,-1/2)$: Yes!

$(1,-1/2)$: That will settle it.

$(2,-2)$: (*as she holds up the placard and substitutes values*) No—— 4 plus 14—— she doesn't satisfy.

$(1,-1/2)$: I told you so.

$(-1,-1/2)$: Oh, you— (*sits down defiantly*)

$(2,-2)$: The next girl we have on our list is — this is a queer name— (a,b).

$(3,-9/2)$: (*loudly*) She's too common.

$(-1,-1/2)$: Yes. She changes her name every time you talk to her. I like definite points.

$(-2,-2)$: She's just trying to make an impression—agrees with everyone.

$(1,-1/2)$: Besides, she uses too much lipstick.

$(2,-2)$: That seems to be unanimous. We won't need the test. How about $(-4,-8)$?

$(-1,-1/2)$: She'll do.

$(-2,-2)$: She's all right.

$(3,-9/2)$: Nice, quiet girl.

$(2,-2)$: (*applying the test*) 16 minus 16. Yes, she's elected. Now, what about $(1,5)$?

$(-2,-2)$: She's not our type—try the test.

$(2,-2)$: 1 plus 10. She's not elected. Let's see, the next is $(0,0)$.

$(-2,-2)$: Oh, she's swell, a bit naive, but good material.

$(3,-9/2)$: Can we develop her in our equation?

$(1,-1/2)$: Yes, I think she will be an asset to the sorority.

$(2,-2)$: 0 plus 0, yes, she does develop in our equation. She satisfies it. The last name is $(-4,-9)$.

$(3,-9/2)$: She's too negative, no personality.

$(-1,-1/2)$: Everytime someone's different from you, you think she has no personality. I think she's nice.

$(-2,-2)$: Oh, try the test.

$(2,-2)$: 16 minus 18, she doesn't satisfy our requirement. Then we've elected $(-4,-8)$ and $(0,0)$. (*There*

is a knock at the door.) Here is $3 \alpha - \beta$ and the frosh. Are you ready for pledging?

Others: Yes.

[$(2,-2)$ *admits all other characters except* (∞). *The sororities line up on opposite sides of the table, the first of each holding the name placard. The freshmen stand in the front, facing the table.* $(0,0)$ *lags behind timidly.*]

$(-4,-8)$:   (*to* $(0,0)$) What's the matter? Come on up.

$(0,0)$:   They don't want me. (*She continues to look doleful until her name is called when she evinces great surprise.*)

$(2,-2)$:   Freshmen, after very careful consideration, we have chosen two of your number to join our order. Election to $\alpha^2 + 2\beta$ is not only an honor, and an opportunity for social contact, but a duty as well. Our curve has a tradition that extends back further than anyone can remember, and that tradition must continue smoothly and without interruption. Before we call on our new members, we will present our old members to you, and the tracer will disclose our history to you. (*As each member says her name* $(1,-1/2)$ *makes a cross on the graph for that point. When all the names have been given, she connects only those parts of the graph including them. When the freshmen have been chosen, she then completes the curve.*) We now request $(-4,-8)$ to join us and complete an important part of our group. (($(-4,-8)$ *goes to the table.*) Will you continue to follow the meaning of $\alpha^2 + 2\beta$?

$(-4,-8)$:   Always.

$(2,-2)$:   We also include $(0,0)$ . . . a very important addition to our curve. (*to* $(0,0)$) Do you promise to follow our curve?

$(0,0)$:   Yes.

[$(2,-2)$ *indicates to* $(-1,-3)$ *that she has finished, and rejoins her sorority.* $(-1,-3)$ *steps forward.*]

$(-1,-3)$:   We shall now present the members of $3 \alpha - \beta$ to you. (*As the members say their names* $(-2,-6)$ *marks them on the graph, and then draws in the negative part of the line, continuing through the origin after* $(0,0)$ *has been chosen.*) Our sorority elects but

one member this year . . . (0,0).

(0,0):   I? Oh, I can't believe it!

(−1,−3):   Will you join us?

(0,0):   Oh, yes!

(a,b):   Huh! Such taste. Who wants to be on a curve, anyway?

(−1,−3):   At last $\alpha^2+2\beta$ and $3\alpha-\beta$ have met again. And the unusual qualities of (0,0) have brought us together. No one else could have done so much for this college . . . I propose three cheers for (0,0), familiarly known as the origin.

All but (a,b): Hurrah for the origin! Hurrah! Hurrah! Speech!

(0,0):   All I can say is that I owe it all to my parents, the axes!

ANOTHER CONVECTION EXPERIMENT.
By HOMER W. LeSOURD,
Milton Academy, Milton, Mass.
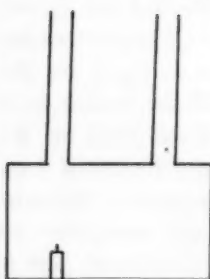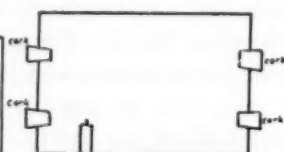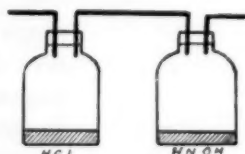
FIG. 1   FIG. 2   FIG. 3

For demonstrating convection currents in air many teachers make use of glass-sided boxes with a burning candle to give motion to the air. The two most common forms are shown in figures 1 and 2. In using these there is some difficulty in finding a satisfactory means of showing the circulation of air since smoke from any source will rise. The apparatus shown in Fig. 3 gives white fumes of ammonium chloride if one blows into the tube at either end of the apparatus. Fortunately these fumes are of about the same density as air and therefore show ascending or descending air currents. These fumes also serve to show convection currents in a heated room.

CREDIT AND RECOGNITION DUE THE SCIENTIST.

By A. C. Monahan,

Formerly U. S. Bureau of Education.

In a recent editorial headed SEEDS OF PROGRESS, Collier's Weekly says: "Behind all these economic problems lies the ferment of scientific inventions. Our civilization was made in laboratories. What we shall be in a few years hence depends upon what men and women skilled in research are able to learn.

"Progress is being made in that sector. Never before have chemists, physicists and biologists been more fruitful in their efforts to extend knowledge and to make available new processes and new tools. We are in the midst of a golden age of scientific discovery."

What further recognition could the scientist ask than is expressed in the above. What better statement could be made to show the teacher of science the importance of his work. What greater incentive could be offered the high school instructor in the sciences to make his department better and better, for it is in his department that the boy or girl gets or fails to get a start along the road to become a scientist. In the high school the future of the student is determined to a great extent. In the science courses he will find out if he has the necessary liking and aptitude to warrant his continuing in scientific classes in the college and university. He can do this, of course, only in a good science course. A poor course, poorly taught, in a department poorly equipped, disgusts him, and his interests turn to other subjects before he has had a real opportunity to know whether he has a special aptitude for science.

The high school science instructor has a great responsibility to the scientific world. He is the one man who is in a position to come in early contact with boys and girls with science aptitudes and to encourage them to go on to further training in colleges and universities. He must be able to tell them of the opportunities before them and something of the kind of work they will do as scientists. He needs to know something of the types of research work done in the 1620 industrial research laboratories in the United States listed by the National Research Council,

and in the 600 U. S. Government laboratories, the college and university research laboratories, the State, city and county laboratories, and those maintained by hospitals and other institutions. For scientists of the highest grade who prefer teaching to research there are over 1,000 colleges and universities employing from three to several hundred scientists each. If a student after completing a college course decides he does not want to enter either the research or teaching field, there are thousands of positions open in control work in manufacturing establishments and hospitals for which a high degree of science training is essential. The instructor should himself visit and take his pupils to visit the different types of laboratories that may be located within his reach. Pupils who see scientists at work in their laboratories, see the kind of work undertaken, and see the laboratories themselves, have a background which enables them to understand something about what the great number of research, development and control scientists are doing in the industrial plants. It means much more to them in an educative way than merely being told about the work, just as their own individual laboratory work gives them an understanding that they would not get from a textbook study alone.

All of the above might be taken to mean that the high school science instructor's principal job is to select and prepare certain especially bright pupils for college entrance. Such is not intended. He has another group to which he should give special attention, those who are not going on to college work but who are going into occupations in which they require a certain amount of science training. He has also pupils who are majoring in some other subject but who will need science training in connection with it—chemistry, physics and bacteriology for the home economics pupil and the student in agriculture, for instance. Again he has a group who are in the science courses because of their real or supposed interest in scientific information. The purpose of each of these groups is not so different that they need be separated into different classes. There can be a certain amount of differentiation in the same class between students who are

studying the subject for the various reasons given. If each pupil, with the help of the instructor, will make a tentative selection of the purpose of the science course to him, he will watch for the applications of the subject at every point of advancement.

When the high school science instructor has properly convinced himself that his courses are the most important in the whole curriculum for those pupils who have a scientific bent of mind together with the mentality to pursue and to profit by them, he will have such a pride in his department that he will take steps to let others know of its importance. He will not do this by talk and argument, but by developing his department until its popularity and worth are reflected in a larger enrollment, and the things being done in its laboratories are the principal subjects of conversation among the students. It is not a difficult task when one remembers that the sciences, with every educational factor in their favor, are backed by a tremendous popular interest in every home from which the children come, by interest in the daily papers, magazines and on the part of the general public. To accomplish the above task there are certain essentials.

The science instructor must know his subject. This does not mean that he must have a doctorate in any of the sciences, but he should have at least two years of college work in any science subject that he attempts to teach, and of course good courses in the other sciences. In addition, he must do a very large amount of reading as the sciences are progressing with new developments almost daily. These are reported for his benefit in the various science journals and at science meetings. He should attend such meetings whenever possible. Relatively few high school science teachers are now seen at meetings of the American Chemical Society, the Physical Society, the American Association for the Advancement of Science, and other national meetings. Even the Science Sections of most of the State Teachers' Association meetings are poorly attended and do not have a very important place at the association meeting. This could be easily remedied.

The science teacher must make his teaching vital. He

must have definite objectives. His courses are educative and cultural, and are developers of mentality, the powers of reason and logical thinking; and they are character builders. They are informational, and have all the other elements of education that we pedagogues claim for the courses we are teaching. In addition they are vital with practical applications in life for all the students who pursue them.

His methods of teaching must be adapted to his pupils. He must remember that they are not far from the adolescent age and that they are still more interested in physical activities than purely mental. He may prefer and find it easier to devote his time to instructor-demonstration-lecture work, and his pupils may absorb as many science facts by that method as by any other. It is questionable whether or not they will take the same interest in and retain the facts absorbed, as they would had they secured the same facts by individual laboratory work performed by themselves. By individual laboratory work, also, they have the chance to learn the technique of solving laboratory problems and the technique of the use of science apparatus. The instructor has to make a careful study to determine which experiments should be done by him and which by the pupils.

His laboratory must be kept in an orderly condition. It should be equipped with standard factory-built furniture. The day of home-built furniture for the laboratory has passed with the day of home-built seats and desks in the classroom. The materials must be kept in good condition and in their proper places. Apparatus, equipment and supplies in their proper places on the shelves encourage neatness in work, which is an essential in science training. Science is an exact subject. It cannot be expected that students will be exact in their work if they work in a slovenly laboratory with instruments that are not kept clean and in condition.

With these essentials cared for the instructor is in a position to advertise his department. Perhaps such an expression might be misleading. One is apt to think immediately of posters about the buildings encouraging enrollment in the science classes. The writer has seen

such in actual use, but does not recommend them. Miss Mary Woolley, in the December SCHOOL SCIENCE AND MATHEMATICS, tells how to use posters although she would hardly regard them as advertising matter. Hers are charts illustrating manufacturing processes studied by the pupils as projects in the chemistry class: "One type was the combination of explanatory chart and samples of materials; a second was made by using materials secured from a manufacturing company, in combination with an explanatory chart made by the pupils; a third was a chart secured from a manufacturing company and a chart of materials secured by the students."

A high school physics teacher in a public high school in New Jersey doubled his enrollment in one year through a plan which is possible in almost any school. He brought the physics department to the attention of the school by giving four demonstration lectures to the entire school in the school auditorium during the year. In them he was assisted by his pupils. The demonstrations were scientific, but spectacular and simple enough to hold the interest of the underclass pupils. They were all about things in which there is much general interest: refrigeration, radio, wave motion, color, and ventilation, etc. The younger pupils are interested in seeing the older ones help in the demonstration, and particularly in learning something definite of what Physics is about and that it concerns many things of great interest—and is not simply an advanced course in Mathematics. These demonstration lectures have been the most welcomed program of all the auditorium programs of the school. The children have talked about them so much in their homes that the Parent-Teacher Association of the school invited the physics instructor to repeat them at their meetings. No other department has today the regard on the part of the pupils, fellow teachers and the public as has that department.

Another physics teacher in an Illinois high school held a science apparatus exhibition in the school building, to which the public was invited. He set up various experiments and demonstrations, each in charge of a couple of pupils, and had constant demonstrations as at the com-

mercial booths at educational meetings that are set up by scientific apparatus manufacturers. He borrowed many pieces of apparatus from manufacturers to make his exhibit more complete and interesting to the public. They were interested and attended in large numbers. Pupils of the school not enrolled in the science courses came in large numbers and were a little envious of those helping in the exhibit. It resulted in a greatly increased interest in the science classes on the part of both the public and the student body. It gave the Physics Department a standing it had never had before. Incidentally this and other good work being done by this instructor brought him to the attention of the manufacturers of a particular scientific apparatus and they took him from the teaching field to their work for a much larger salary than the school thought it could pay.

The science club in the high school is a very common organization. As usually conducted it has not been particularly satisfactory in increasing interest in science classes. In many cases it has been to the average student just another class period with pupils conducting the class instead of the teacher; or an outside speaker who proved rather difficult to understand and not very interesting. In some schools the club has been effective. Usually where this is the case it is open to all pupils in any of the science classes as full members and to other pupils as associate members. The programs are usually pupil efforts, with a little rivalry developed between the students in different subjects to outpass each other. This plan has usually increased the interest and enrollment in chemistry and physics because the pupils in general science and biology in the underclasses have had their interest aroused by the advanced work in these demonstrations. One very successful club usually arranges its program so as to have the demonstration at any meeting conducted by upper classmen though upon some topic in general science and biology in which the lower classes are engaged at that time. Several successful plans for clubs are described elsewhere in this journal.

THE PROMOTION OF HIGH SCHOOL SCIENCE INTEREST THROUGH SCIENCE CLUBS.

I. THE ILLINOIS JUNIOR ACADEMY OF SCIENCE

H. Carl Oesterling, Urbana, Ill.

The following brief history of the Junior Academy of the Illinois State Academy of Science was prepared by Lyell J. Thomas and Arthur C. Walton, past and present secretaries of the Illinois Academy. It gives a quick review of the steps leading to this organization, consummated in 1929, which is infusing new spirit, life and purpose into the High School Science Clubs of the State.

"For a number of years prior to 1926 the policy of the Illinois State Academy of Science was one of encouraging and fostering high-school science clubs with the hope that this would stimulate interest on the part of young people throughout the State in science in general ultimately leading to increasing the membership of the State Academy. But, contrary to the expectation of the council and officers, no marked increase in interest was noted, although a few high-school science clubs did affiliate with the Academy. Such clubs generally had enthusiastic teachers behind them. At the annual meetings the science section devoted to high school science and clubs became a constant source of worry to the secretary because of the difficulty encountered in developing programs of sufficient interest to bring out high school teachers. The teachers' interest was considered at that time the first objective and student interest was regarded as secondary. The section consequently catered only to teachers' interest.

"In the 1928 meeting of the Academy the attention of the secretary was drawn to what seemed to him the real objective—a high school student presenting before the High-School Science Section a demonstration of what he was interested in—a project study in the field of chemistry. That student's teacher, Miss Aleta McEvoy, of Rockford High School, was made chairman for the following year of this science section.

"Up to 1928 the State High School Teachers Conference had held aloof from any affiliation with the State Academy. That year the Secretary sought for the affiliation

of the State High School Biology Teachers Association and the State High School Chemistry Teachers Association, with the result that both Associations were added to the list of societies affiliated with the Academy. By this means, academy projects and problems of interest to science teachers could be brought before the teachers' organizations at their regular annual Fall conferences. Dr. Rosalie M. Parr, who was then Secretary-treasurer for the State High School Chemistry Teachers' Association, cooperated with Miss McEvoy in formulating a plan whereby student interest might be developed in the meetings of the State Academy. The result was the organization of the Junior Academy of Science. This organization, made up of delegates from high school clubs, met first with Miss McEvoy at the annual meeting in Macomb, in May 1929. Thus in a great measure the Illinois Junior Academy of Science supplanted the old High School Science Clubs section of the Academy, with enthusiastic high school students instead of slightly apathetic teachers. About thirty-five high school student delegates attended the Macomb meeting of the Academy, and actual participation of high school students in an Academy meeting was achieved."

The Junior Academy of Science welcomes all clubs in any high school, senior or junior, who are interested in science club work. The club may be a Biology, Bird, geology, radio, astronomy, chemistry, etc., or it may be a combination of biology, chemistry and physics—the latter being the type of club most common in the schools.

A high school science club is a group of students interested in science, organized into a club for the purpose of studying and developing scientific subjects, to create a greater interest in the science in their own community, and to call to the attention of the people of their community the accomplishments of science. The club is a student activity under the supervision of one or more faculty advisors. There is generally a president, vice-president, secretary and treasurer—chosen from upper classmen.

All that a club must do to become a member of the Junior Academy is to send a money order for two dollars

made payable to the treasurer of the State Academy of Science, to cover the initiation fee of one dollar and the annual dues of one dollar per year for a club. All members are entitled to wear a pin bearing the State insignia and a guard with their club insignia. The pin will in time mean more to its members than a fraternal pin.

All affiliated clubs are entitled to send delegates to the State meeting, but only three from each club are entitled to vote on the questions of this meeting, which will be in the hands of the student officers under the supervision of the State executive committee.

II. SCIENCE MOTIVATION AND THE SCIENCE CLUB.

Alice Rosenthal, Edward Everett School, Dorchester, Mass.

In the adolescent pupil, the desire for membership in some sort of organization is very strong. The school club offers an excellent opportunity for utilizing this instinct. A vital, worthwhile club will enrich the outside interests of pupils and at the same time will create a greater liking for the regular school work.

For several years we have had a science club at our school. About twenty-five boys of the seventh and eighth grades belong and meet weekly for an hour. A committee of five boys drew up the constitution, wherein appears the organization of the club, together with the name, purpose and membership requirements. The membership of the "Junior Science Club" were unanimous in their desire for a club pin and color.

The preparation of a suitable weekly program was the most difficult task. The executive committee of three boys gave much thought and study to this phase of the club work. The regular meetings include a reading of the secretary's report, a discussion by members, of the current science news, reports from the lives of the scientists whose birthdays occurred during the week, talks and demonstrations by the club members on their individual projects.

Each boy selects each year some topic in science in which he especially is interested and works on it throughout the year. Some boys made aeroplanes, telegraph sets, radios, and the like; others chose chemical experi-

ments; a few preferred to work on written problems such as "Our Presidents as Scientists," "Myths and Legends in Astronomy," "History of Aviation."

As we all know, repetition tends to destroy interest. Consequently, we occasionally vary the program with lantern slides, by having entertainments or taking excursions to places of scientific interest.

An outstanding feature of the club work is an annual scientific demonstration in the assembly hall in the presence of the student body. The last program included 1. An experiment in color. 2. A home made telegraph set. 3. Kindling fire without matches. 4. An experiment with fire-foam. 5. A Boy-Scout test in artificial respiration. 6. The transformer. 7. Making ink. 8. The Boston Consolidated Gas Company. 9. A project in wiring bells. 10. A play illustrating common applications of Science.

A properly organized science club will undoubtedly motivate the regular science work of the school. In my estimation, the club period should occur during the school hours, and be sponsored by a teacher who is in sympathy with the club movement. Occasionally a teacher may say that science, because of its instinctive appeal does not require such motivation as the more abstract subjects. However, no matter how attractive a subject may be in itself, no real teachers of science will fail to employ anything that will bring added enthusiasm for the subject they are teaching.

HOME MADE FURNITURE.

By GEO. P. UNSELD, *Salt Lake City*.

On page 55 of the January number of this journal there is a statement to which we would make exception. In all the science rooms of our building the furniture is "home made." It has been in use nine years and has given complete satisfaction. We are now building a new high school and expect to experiment by covering the laboratory tables with heavy linoleum. It is expected that this will improve the appearance of the rooms, because, otherwise the old tables are O. K. The money saved in this way, which amounts to several thousand dollars, can well be put into additional instruments.

One can readily see that "home made" furniture might not be satisfactory. It all depends on how it is made.

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,

Illinois State Normal University, Normal, Ill.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution as on the following pages.

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.

Editor. Persons sending in solutions should read carefully the instructions about the form of the solutions and the ink-drawn figures. Many times, a good solution is received, but poorly arranged and no india-ink figure given.

LATE SOLUTIONS.

1146. *Proposed by Lu Chin-Shih, Soochow Univ., Soochow, China.*

If a line is parallel to one side of a triangle, it divides the other two sides into proportional segments. Prove the case when the sides are divided into irrational segments by means of the synthetic method. Do not use the indirect method, or involve any idea of limits.

Solved by the Proposer.
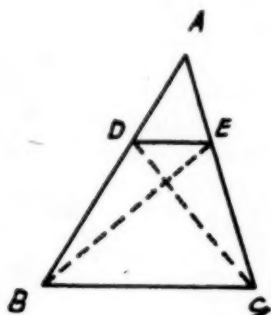
(1) Join B, E and C, D.

∵ (2) △ DAE and △ DEC have the same altitude h from D to the base AE or EC.

∴ (3) $\dfrac{\triangle DAE}{\triangle DEC} = \dfrac{AE \cdot h}{EC \cdot h} = \dfrac{AE}{EC}$.

(4) Similarly △EAD and △EDB have the same altitude h' from E to the base AD or DB.

(5) $\dfrac{\triangle EAD}{\triangle EDB} = \dfrac{AD \cdot h'}{DB \cdot h'} = \dfrac{AD}{DB}$.

∵ (6) △DEC and △EDB stand on the same base DE and between the parallels DE and BC. It follows that △DEC = △EDB.

(7) But △DAE = △EAD; and $\dfrac{\triangle DAE}{\triangle DEC} = \dfrac{\triangle EAD}{\triangle EDB}$

∴ (8) From (3), (5), and (7) we know that

$$\frac{AE}{EC} = \frac{AD}{DB}.$$

Note:—The above proof always holds, no matter whether the sides are divided into rational or irrational segments. But in order to put it in a text book, the text book must have the chapter on Area before the chapter on Proportion.

1148. *Proposed by Walter Carnahan, Indianapolis, Ind.*

In Altshiller-Court's "College Geometry" page 66, the following statement is given: "A triangle may have two equal external angle bisectors and not be isosceles." Give a figure to illustrate and prove.

Solved by Lu Chin-Shih, Soochow Univ., Soochow, China.
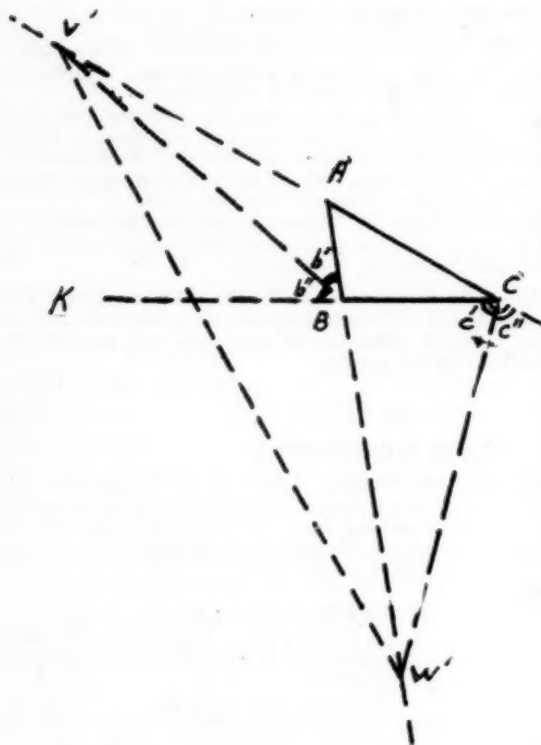
(1) The external angle bisector, in this sense, means the length of the segment of the bisector from the vertex of the angle bisected to the point of intersection of the bisector with the side of the triangle opposite to the angle concerned.

(2) In the figure BV' and CW' both satisfy the required condition for an external bisector as stated in (1), and therefore we may see from the figure that BV' = CW' but AB and AC are apparently unequal.

It may be proved as follows:

Given:—
$\angle b' = \angle b''$, $\angle c' = \angle c''$, and BV' = CW'.

To prove:—
AC > AB.

Proof:—

(1) Join V', W'.
$\because$ (2) $\angle b' + \angle A$ BC $< \angle b' + \angle b'' + \angle ABC = 180°$.

(3) $\angle b'' + \angle KBW' = \angle b' + \angle ABC < 180°$, since $\angle b' = \angle b''$ (given) and $\angle KBW'$ and $\angle ABC$ are opposite angles.

$\therefore$ (4) V'W' lies on the opposite side of BV' with AV' and on the opposite side of BW' with CW'; i.e., $\angle AV'W' > \angle BV'W'$ and $\angle CW'V' > \angle BW'V'$.

(5) $\angle c''$, the external angle of $\triangle CV'W' = \angle AV'W' + \angle CW'V'$.

(6) $\angle b'$, the external angle of $\triangle BV'W' = \angle BV'W' + \angle BW'V'$.

(7) From (5), (6), and (4) we know that $\angle c'' > \angle b'$, or $2 \angle c'' > 2 \angle b'$.

(8) But $\angle ABC + 2 \angle b' = 180° = \angle ACB + 2 \angle c''$.

(9) Subtracting (8) from (7) we get $\angle ABC > \angle ACB$.

(10) Therefore in $\triangle ABC$, AC > AB.

SOLUTIONS OF PROBLEMS.

1151. *Proposed by I. N. Warner, Platteville, Wis.*

A farmer bought a straight-up open top rectangular tank measuring 3 ft. 6 in. wide and 5 ft. 6 in. long (inside measure). It was brought home and placed in a level position. During a shower of rain, 3 gallons of water were caught in the tank. What depth of rainfall was that shower?

Solved by Harry Frye, Tullahoma, Tenn.

3 ft., 6 in. = 42 in.; 5 ft., 6 in. = 66 in.; 1 gal. = 231 cu. in. Let X equal the number of inches of the rainfall. Then

$$42 \times 66 \times X = 3 \times 231.$$
$$X = \tfrac{1}{4} \text{ in.}$$

Also solved by *James McDowell, Plainwell, Mich.; Edward M. Tucker, Georgetown, Mass.; Albert Schwartz, Perth Amboy, N. J.; F. G. Tacquard, Austin, Texas; W. E. Batzler, Battle Creek, Mich.; Rod Holmgren, Kenneth*

Jacobson, Morton Kantoff, Seymour Hershman, Robert Muehlberg, Irving Cherman, Leo Lubliner, Roosevelt H. S., Chicago, Ill.; Leroy Davis, Cedarville, Ohio; R. T. McGregor, Elk Grove, Calif.; Margaret Joseph, Milwaukee Wis.; Hazel E. Fliess, Clifton Forge, Va.; Elizabeth Allen, New York City; Bert Norbert, Trinity H. S., Chicago, Ill., and Alice Barkhuff, Touchet, Wash. One incorrect solution was received.

1152. *Proposed by S. Chuang, Ping-yang-fu, Shansi, China.*

Surd numbers can be expressed as a series of rational fractions. Prove that

$$\sqrt{2} = 1 + \frac{1}{2} - \frac{1}{2x5} + \frac{1}{2x5x7} - \frac{1}{2x5x7x197} + \cdots$$

Solved by E. B. Escott, Oak Park, Ill.

The convergents to $\sqrt{2}$ are of the form U_n/V_n, where U_n, V_n are connected by the relation

$$(1-\sqrt{2})^n = U_n - V_n\sqrt{2}.$$

From this relation we can obtain

$$U_{2n} = 2U^2_n - (-1)^n \text{ and } V_{2n} = 2U_nV_n.$$

Then we may get

$$(U_n - V_n\sqrt{2})2U_n - (-1)^n = U_{2n} - V_{2n}\sqrt{2}$$

By these relations

$$(1-\sqrt{2})2 + 1 = 3 - 2\sqrt{2}$$
$$(3 - 2\sqrt{2})5 - 1 = 2(7 - 5\sqrt{2})$$
$$(7 - 5\sqrt{2})14 + 1 = 99 - 70\sqrt{2}$$
$$(99 - 70\sqrt{2})198 - 1 = 19601 - 13860\sqrt{2}$$
$$(19601 - 13860\sqrt{2})39202 - 1 = 768398401 - 543339720\sqrt{2}.$$

Commencing with the last quation, making consecutive substitutions, and rearranging terms of final expression, we get

$$\sqrt{2} = 1 + \frac{1}{2} - \frac{1}{2x5} + \frac{1}{2x5x7} - \frac{1}{2x5x7x197} + \cdots$$

Also solved by Louis R. Chase, Newport, R. I.

1153. *Proposed by I. N. Warner, Platteville, Wis.*

(Taken from Macnie's Geometry, page 187, Ex. 499)

C is the center of a circle. On any diameter take two points, as O and Q, equidistant from C. If through one of these points, a chord be drawn, as AB and then A and B be connected with Q, then the sum of the squares of the sides of the triangle thus formed is constant.

1. *Solved by Louis R. Chase, Newport, R. I.*

Since BC and OQ are constant, $a^2 + x^2$ is constant; similarly, $b^2 + y^2$ is constant. (The sum of the squares of two sides of a triangle is equal to twice the square of half the third side increased by twice the square of the median upon that side.) Therefore $a^2 + b^2 + x^2 + y^2$ is constant. (1)

Now, xy is constant, being equal to OM times ON. (If two chords intersect within a circle, the product of the segments of one is equal to the product of the segments of the other.) Adding constant $2xy$ to constant (1), we have as a constant, $a^2 + b^2 + x^2 + 2xy + y^2$, which is equivalent to $a^2 + b^2 + \overline{AB^2}$.
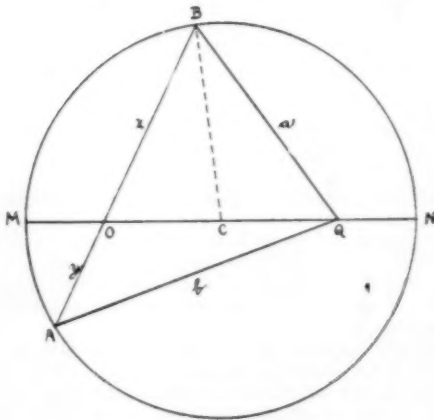
Solution II. *Albert Schwartz, Perth Amboy, N. J.*
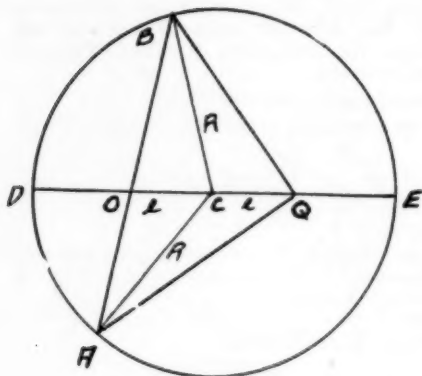
(1) $OB \times OA = DO \times OE$
$= (R+l) \ (R-l) = R^2 - l^2$

(2) $2 \ OB \times OA = 2R^2 - 2l^2$

(3) $4l^2 + 4R^2 = 2(OB)^2 + 2(BQ)^2$

(4) $4l^2 + 4R^2 = 2(AO)^2 + 2(AQ)^2$

(5) $(AO)^2 + (OB)^2 + 2(AO)(OB) + (BQ)^2 + (AQ)^2 = 6R^2 - 2l^2$

(6) $(AB)^2 = (AO)^2 + 2(AO)(OB) + (OB)^2$

Substituting value of $(AB)^2$ in (5) we get

$(AB)^2 + (BQ)^2 + (AQ)^2 = 6R^2 - 2l^2 =$ a constant.

Also solved by *R. T. McGregor, Elk Grove, Calif.; Leroy Davis, Cedarville, Ohio; Lu Chin-Shih, Soochow, China; Edward M. Tucker, Georgetown, Mass.;* and *Guy C. Lentini, Boston, Mass.* One solution received with the name of the solver omitted.

1154. *Proposed by the Editor.*

A weather vane on a ship's mast points northeast when the ship is headed due east at 16 miles per hour. If the velocity of the wind is 20 miles per hour, what is the true direction of the wind?

Solved by Leroy Davis, Cedarville, Ohio.

From the law of Sines, Sin A = a sin B/b = 16 sin 45/20 = .56568

A = 34° 26' 56". Hence the true direction of the wind is from 45° − 34° 26' 56" = 10° 33' 4" E. of N.

Also solved by *W. E. Batzler, Battle Creek, Mich.; R. T. McGregor, Elk Grove, Calif.; Louis R. Chase, Newport, R.I.*

Four incorrect solutions were received.
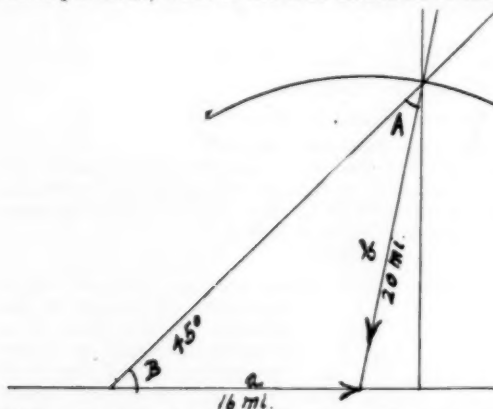
1155. *Proposed by Louis R. Chase, Newport, R. I.*

Given the line of the base, midpoint of base, vertex angle; to construct the triangle. A geometrical solution is desired.

Solved by G. P. Barkhuff, Touchet, Wash.

Let AB be the given base with the midpoint C given and D the given vertex angle.

Lay off the line AB and at one extremity, as at B, lay off an angle equal to angle D and extend one side of the angle thro the vertex B as per diagram. Erect perpendiculars to AB at C and to BE at B and continue them until they intersect at O. With OB as a radius describe a circle passing through AB and making it a chord

From any point on this major arc AB such as P draw lines to the extremities of chord AB. *This is the required triangle. Proof.* This is based on the fact that the angle between a chord and a tangent is measured by ½ the intercepted arc AB. Also an angle inscribed in a circle is measured by ½ the intercepted arc AB.

Also solved by *Elizabeth Allen, New York City; F. G. Tacquard, Austin, Texas; and Lu Chin-Shih, Soochow, China.*

1156. *Proposed by E. de la Garza, Brownsville, Texas.*

A father and his son work together. The father, after a certain number of working days, receives a total pay of $72. The son, having worked 5 days less, receives $50. If the son had worked as long as the father, and if the father had worked 5 days less, they would have received the same total pay. Find the number of days that each worked and the wage per day.

Solved by Hazel Estelle Fliess, Clifton Forge, Va.
Let X represent the number of days the father works.
Then $72/X$ = the father's daily wage.
$X - 5$ represents the number of days the son works.
$50/(X-5)$ = the son's daily wage.
Hence by the conditions stated,

$$\frac{50X}{X-5} = \frac{72(X-5)}{X}$$

From this equation, $X = 30$ days, and father's wage is $2.40.
The son worked 25 days, and his wage is $2.

Also solved by *Frederick C. Helfesrieder, St. Louis, Mo.; Joseph L. Stearn, Brooklyn, N. Y.; Albert Schwartz, Perth Amboy, N. J.; Edward M. Tucker, Georgetown, Mass.; Sudler Bamberger, Harrisburg, Pa.; E. E. Cook, Philadelphia, Pa.; F. G. Tacquard, Austin, Texas; W. E. Batzler, Battle Creek, Mich.; Leroy Davis, Cedarville, Ohio; Harry Frye, Tullahoma, Tenn.; Helen G. Crozier, Fortuna, Calif.; Margaret Joseph, Milwaukee, Wis.; Alice Barkhuff, Touchet, Wash.; Elizabeth Allen, New York City; Agnes Caprez, Chicago, Ill.; Bert Norbert, Chicago, Ill.; James McDowell, Plainwell, Mich.;* and the *Proposer.* One solution received with name of solver omitted.

PROBLEMS FOR SOLUTION.

1169. *Proposed by Norman Anning, University of Mich.*

Show that a proof of 1142, page 951, November issue, can be obtained from a study of an expression for the distance between the orthocenter and circumcenter of a triangle.

1170. *Proposed by a Reader, East Orange, N. J.*

Show that six times the sum of the eleventh powers of the first n whole numbers is exactly divisible by the sum of the cubes of those numbers.

1171. *Proposed by Louis R. Chase, Newport, R. I.*

Point O lies outside the straight line ABCD. AO = 100 ft., OD = 125 ft., and BC = 60 ft. Angle AOC = angle BOD = 90 degrees. Find the length of AD.

1172. *Proposed by I. N. Warner, Platteville, Wis.*

(Exercise 504, page 187, Macnie's Elements of Geometry).
If from the same point a secant and two tangents be drawn to a circle, then the secant will be divided harmonically by the circumference and the chord joining the points of tangency. Prove.

1173. *Proposed by W. E. Buker, Leetsdale, Pa.*

Right triangles A, B, and C, all sides integral, have equal areas. Find the values of the sides of the triangles.

1174. *Proposed by Guy C. Lentini, Boston, Mass.*

A concern manufactures a mechanical appliance in 8 sizes. The price list, which is changed once a year, is always arranged so that the price bears a linear relation to size. Which buyers were not affected by the price changes for 1930 if the value of the smallest machine rose four dollars and that of the largest fell ten dollars?

ORGANIZING THE SECTION OF THE STATE EDUCATION ASSOCIATION, "THE HEART OF THE CONVENTION."

By B. F. Baldwin,

Chairman of Science and Mathematics Section, Eastern District, Montana Education Association.

Several years ago some one originated the slogan for Montana Education, "The Sectional Meeting, the Heart of the Convention." This is a fine slogan, with splendid intentions since it places emphasis on the section. It does not, in many cases, have fulfillment under the present order of things at our conventions. Where failure exists, the cardinal reason is not a lack of desire on the part of officers, but resolves itself into a matter of time.

The average sectional meeting starts placidly, ending in a furor of argumentative enthusiasm which consumes the allotted one hour and a half, or perhaps it starts half-heartedly and never emerges to a higher level. These meetings are both undesirable, and yet each has its points of favor. There must be enthusiasm, but this quality should be regulated by a well prepared and executed program. Such a program will carry a few subjects to a logical conclusion and will not allow discussional enthusiasm to break up the meeting, leaving a dozen matters "in the air." This type of program can hardly be achieved without a well working organization; an organization functioning throughout the year.

The officers of the Science and Mathematics Section of the Eastern District noted this condition within their own group, and two years ago, set out to relieve the situation. The machinery set up is now in its second year of life, and has, we believe, a record of one good year behind it. It is being directed in the present year by some of the same officers and committees as those of last year. We feel that a two year tenure for officers would give a greater continuity to the programs. However, this has not become an established part of our program.

The time element, we agreed, was our stumbling block at the convention. There were too many subjects raised and dropped, too many topics covered with enforced rapidity, and many important problems still "on the table" when the final whistle blew. More time had to be

given to our problems than we could find at the convention. This could only be accomplished by an all-year program instead of a strictly convention program. Our new program, therefore, has two features; the convention program, and the all-year program, with definition of purpose as follows:

1. The Convention Program
   A. The summing up of the past all-year program
   B. The organization of the future all-year program
2. The All-year Program
   A. Commission studies
   B. Individual studies
   C. Publication of a sectional bulletin to keep members in touch with each other and with the results of the program as it progresses

Under this plan the convention meeting is fundamentally, a meeting to decide what our schedule for the coming year will be and who will direct it. The organization perfected at the meeting is much more effective than any made through correspondence.

Our 1930 convention meeting was based on this plan, and gave a more definite idea as to what progress was being made. In line with our definition of purpose, the first session brought the year's work to a close with a summary in the form of a debate. This debate was presented in regulation style and presented the arguments pro and con the "Recitation." The constructive speeches were based on the findings of committees through the use of the bulletin and questionnaires, investigation being in progress throughout the entire past year. The outcome of this debate, was, on the second day, to set up a new program for 1930-31 suggested by the conditions reported in the 1929-30 studies.

The initial step in organization was the election of officers and the second session was placed at their disposal for outlining the new all-year program. The officers had a private session and laid their plans. Commissions were appointed, work and responsibilities divided. As an example, a commission was appointed to carry out the desire of the section that they enter into

a district-wide study of improving classroom procedure.

Realizing the need of expert direction in any experimental study, the commission immediately consulted the university representatives at the convention. Through these consultations, we have had placed at our disposal the research bulletins of Columbia and Chicago Universities. Dr. W. L. Beauchamp of the University of Chicago is personally interested in helping us outline our study on an air tight basis. Columbia has intimated they should like to assign the project to some man as a doctorate. We, therefore, feel that organization "on the spot" has paid us, and that when we launch our district-wide study in January we will be doing something worth while for every teacher who participates.

The second and third features of the all-year program are the individual studies and the publication of the bulletin. The individual study may be voluntary or assigned. The results of this personal work, whether research or first hand experiment, are disseminated through the bulletin. The bulletin is edited by the secretary of the section. The cost of publication is supported by a fifty cent subscription. I must acknowledge the very fine co-operation of Superintendent Harris' office of Hardin during the first year of publication. During the past year, we mailed 75 bulletins each month. Our bulletin carried summaries of some very fine original work under such titles as "Speed, Precision, and Accuracy," "Some Projects in Physics," "A Balanced Aquarium," "Interest Holding Stunts in Geometry." In addition to articles of this type many teachers reviewed current articles from their own reading and research. The response was gratifying to the officers. The bulletin gained a unanimous vote for another year of life, and pledges of support, at our last meeting. The first bulletin of the current year is dated November.

The bulletin offers a medium through which the officers may work and keep the morale of the organization at an enthusiastic level. It offers a bond of communcation between the teachers and makes them feel the advantages of co-operation. In 1929 we had a 35% attendance at the sectional meeting. The following year the bulletin

kept pointing toward the Billings convention and the Billings program. This resulted, in 1930, of an average attendance of 45 which is 75% of our membership. This attendance figure is cut by the administrators' sections, since several of our number are principals and superintendents.

Since the purpose of our convention meeting is to sum up the past all-year program and to formulate a new one, we have our 1931 convention program under way at this time. Negotiation has been started to have an expert illustrate the procedure of the Unit Plan through the use of a demonstration class. This will be a likely summary to our year of study.

Our experience indicates that:

1. Sections should set up an all-year program in addition to the convention meeting

2. That they define their programs in order to insure adequate summary, and complete future organization

3. That each section augment its work with a bulletin. Possibly, as need arises, these bulletins should be incorporated in the Montana Education Association Journal.

4. That some permanent tenure for officers be established such as a two year term for chairmen, or an automatic succession from office of vice chairman to that of chairman.

SCIENCE QUESTIONS

A Column of Co-operation in a Magazine of Co-operation.

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

Co-operation is the process of Give and Take. What can you give? What would you like to take? Please help to make this a real Department of Co-operation.

RELATIVITY—A DEFINITION.
An Interview with Professor Albert Einstein.

Albert Einstein, world famous scientist, on his arrival in New York, answered few of the questions, foolish and otherwise, that the reporters shot at him. But he did take time to tell one of them what his theory of relativity is in language the newspaperman could understand. "When a man holds a pretty girl on his lap for an hour, it seems to him a minute," Einstein explained. "But when he sits on a hot stove a minute, it seems to him an hour. That's relativity."— *(Capper's Magazine, March 1931)*

CHOKE COIL AND CIRCUIT BREAKER.

579. *Asked by Andrew T. Frank, 403 S. Fourth St., Girard, Ill.*
"Dear Mr. Jones:

Would you please send me the following information as near as you can? I hope you can find out for me all I want to know.

Would you please tell me how I could make a *choke coil* to be used on a 110-volt A.C. current, so that from 25 to 30 or 35 amperes of current would flow through it. I don't like to use resistance wire because this wastes too much energy due to heat. By using a choke coil this is partly eliminated and does not take much energy. I want to use this on an arc-light for a small electric furnace and I want to use about 28 amperes of current at 110 volts pressure. Could I adjust this choke coil to allow from 20 to 35 amperes of current to flow?

Also, what kind of wire, turns, size, and size of core to be used? I have some silicon steel transformer steel in laminations. Could I use this for the core and what would be the size of it for the current used above?

Also, could you send me information on how to make a circuit-breaker to break the circuit when about 30 or 35 amperes of current would flow through the circuit? Tell the size of core and numbers of turns of wire and size of wire to make it of.

I will appreciate this information very much.

Very truly yours,

ANDREW FRANK."

QUESTIONS AND ANSWERS.

567. *Proposed by Mr. John Skok, Chicago, Ill.*

Mr. Jones:

I have a question in electricity which I would like answered, as I understand you give such discussions in the journal.

In our laboratory work in physics we use a D. C. line which is generated by a D. C. generator in the school. On the switchboard it is marked 110 volts and also 220 volts, although our voltmeter readings are always 110 volts or two or three volts either more or less, but never 220. The switch on the switchboard has three contact points instead of two, and I was told that the P. D. of the middle conductor and an outside one was 110 volts, but the P. D. between the two outside ones is 220 volts. When the switch is closed, all three of these are connected, yet the voltmeter only shows 110 volts.

I don't understand this nor how one generator can generate both 110 and 220 volts at the same time.

I hope you will have time to explain this, and I thank you in advance.

Yours very truly,

JOHN SKOK.

Answer by Professor Lloyd M. Knoll, A. M., 6120 Carpenter St., Philadelphia, Pa.

While it is true that the ordinary three-wire system requires two dynamos, there are several ways of producing the same results employing only one dynamo. Possibly the simplest is as follows: A generator designed to deliver 220 volts D. C. has a pair of collector rings mounted on the armature shaft and each ring connected to equipotential points of the armature winding, i.e., on a two pole machine the points are diametrically opposite. The generator now is able to deliver both A. C. and D. C. at 220 volts. If a choke coil is connected across the A. C. terminals and the neutral wire of the three wire system is connected to the middle point of the choke coil, the E. M. F.s between the neutral and the outside wires will be 110 volts. The self inductance of the choke permits but a small A. C.

current to flow without hindering the flow of the D. C. Thus an unbalanced load is taken care of through the neutral wire and the half of the choke, because the D. C. is not opposed by anything but ohmic resistance.

DR. DYER'S DENTAL SCIENCE.

569. *Proposed by A. C. Norris, McClure, Ill.*

(Please refer to page 964, SCHOOL SCIENCE AND MATHEMATICS, November, 1930, and re-read Mr. Norris' letter. Then send the Editor the name of THE man in your community who might be willing to help with questions. *Editor.*)

I would write to some leading man in his profession asking him to submit from 15 to 30 questions covering their field of activity along the line of Science, both physical and biological.

Dear Dentist: Give me 25 questions covering the field of dentistry.

Dear Criminal Lawyer: Submit 20 science questions you would ask a young man entering your office as apprentice.

Dear Blacksmith: A boy wishes to enter your shop; give me 20 questions he should be able to answer about iron, steel, fuels and related topics.

Questions and Answers by Dr. Harold E. Dyer, Dentist, 1368 Beacon Street, Brookline, Mass.

1. How many teeth in a normal, complete, adult dentition? 32.
2. How many teeth in a normal, complete, temporary dentition? 20.
3. At what age does the first permanent tooth appear? About the sixth year.
4. Does this permanent tooth replace a temporary tooth? No.
5. What is that part of a tooth which is normally exposed to view? The crown.
6. Of what is that part composed? Enamel overlying dentine.
7. Of what is the nerve (pulp) of a tooth composed? Nerve tissue, vein, artery, lymphatic and connective tissues.
8. What are the most common materials used to repair tooth destruction? Gold, silver, amalgam, fused porcelain and cements.
9. What is "silver amalgam"? Silver alloy amalgamated with mercury.
10. What is the active ingredient in most patent stain removing solutions sold for the use of removing stains from the teeth? Hydrochloric acid.
11. What is the approximate percentage of silver in silver fillings? About 67%. (This varies slightly according to the make.)
12. Is the active ingredient in most patent stain removing solutions harmful to the enamel? Yes. A freshly extracted tooth left in the solution for twenty-four hours is so affected that the enamel may be scraped off like chalk.
13. What metals are alloyed with gold to give hardness? Platinum, copper and zinc.
14. What is the method employed in producing the gold inlay? Casting.
15. Will pure gold withstand the stress of mastication? Yes.
16. What pressure is exerted between the teeth (as in crushing food) of well developed jaws of a man? About 250 pounds.
17. What reaction takes place when candy causes a tooth to be sensitive? The sugar, which is anhydrous, withdraws moisture from the dentine at the area which has lost its normal protection of the enamel.
18. What is the base of investments used in dental castings? Plaster of Paris.
19. What is the material most commonly used for artificial dentures (plates)? Vulcanite rubber.

20. Why was X-Ray so called? X equals unknown.
21. What is the Roentgen Ray? The X-Ray.
22. What is "laughing gas"? Nitrous oxide.
23. How many roots has a normal lower molar? Two.
24. What is vulcanite? A chemical compound of caoutchouc (India rubber) and sulphur.
25. What is the all important factor in making two pieces of gold cohere? Absolute freedom from impurities.

Acknowledgment to Dr. Dyer.

The Readers of SCHOOL SCIENCE AND MATHEMATICS are under great obligations to Dr. Dyer for this list of questions.

PHYSICS TESTS—ELECTRICAL MACHINERY.

580. *Submitted by Vance M. Shobert, Head Science Department, Lincoln High School, Midland, Pennsylvania.*

Dear Mr. Jones:

Noticing frequent requests in the SCHOOL SCIENCE AND MATHEMATICS for tests in Science, I am sending a copy of a test used in our Physics. I make frequent use of these tests as a matter of checking the information obtained by the students. While these are called tests, they are used simply as check-ups for the students whereby they might ascertain the weakness in the information they should have obtained about the subject studied.

Sincerely,

VANCE M. SHOBERT.

PHYSICS TEST, No. 8—ELECTRICAL MACHINERY

Read these directions first.

Directions: In these statements the italicized words affect the correctness of the statements. If the statement is correct, place a "T" in the parentheses at the right. If incorrect, place an "X" in the parentheses and the word which corrects the statement on the line.

1. A dynamo consists essentially of a machine for transforming *mechanical* energy into *electrical* energy.   ( ) ———
2. If the machine derives its mechanical power from an outside source and delivers electrical power, the machine is a *motor*.   ( ) ———
3. If the machine derives its electrical power from an outside source and delivers mechanical power, the machine is a *generator*.   ( ) ———
4. Strictly speaking, the term *"dynamo"* includes both generator and motor.   ( ) ———
5. *Edison* discovered that a wire cutting lines of magnetic force, when part of a closed circuit, will produce an electric current.   ( ) ———
6. A simple *generator* may be made by placing a loop of copper wire, carrying electric current and bent in the form of a "U," each limb of the "U" bent at right angles so that it may be suspended and swung freely in suitable supports, in a magnetic field of common horseshoe magnets.   ( ) ———
7. In a Ford *magneto* there is a series of horseshoe magnets attached to a flywheel so that they are moved rapidly past stationary coils, this device producing the current for the car.   ( ) ———
8. A *continuous* current is called alternating current.   ( ) ———

9. To get a continuous current from a generator a device, called a *commutator*, is used. ( ) ————

10. A *magnetic field* may be studied by mapping the picture produced when iron filings are grouped under the influence of magnetism. ( ) ————

11. According to the *right hand rule,* when a coil of wire moves up through a magnetic field in which the lines of magnetic force are from the right to the left, the direction of the induced electromotive force is towards you. ( ) ————

12. It is *not possible* to convert mechanical energy to electrical energy. ( ) ————

13. A simple way to get at the *fundamental idea* of a generator is to think of the induced electromotive force produced in a single wire when it is moved through a magnetic field.

14. If a straight conductor be moved downward through a magnetic field, an *electric current* will be set up in the straight conductor. ( ) ————

15. An electric current is set up even though the conductor is *stationary* in a magnetic field. ( ) ————

16. In order that an electric current might be set up in a conductor, the conductor *may* cut lines of magnetic force. ( ) ————

17. The important factors of Flemings' rule are direction of the motion of the wire, direction of the lines of magnetic force and the direction of the induced electromotive force. Yes or No. ( ) ————

18. Current set up in a conductor when the conductor moves rapidly through a magnetic field cutting the lines of magnetic force is *continuous* current. ( ) ————

19. The *direction* of induced electromotive force depends on the direction of the motion of the magnetic flux and the direction of the conductor. ( ) ————

20. Induced electromotive force may be *increased* by moving a conductor faster through a magnetic field, by making the magnetic field stronger, and by using more loops. ( ) ————

21. Induced current *varies* as speed x flux x turns of wire. ( ) ————

22. *Flux* is directly proportional to the magnetomotive force and inversely proportional to the reluctance of the circuit. ( ) ————

23. In the formula for law of the magnetic circuit, F equals ϕ divided by R. Yes or No. ( ) ————

24. It will help to understand what is happening in a coil revolving in a magnetic field, if one can analyze what takes place in a single loop revolving in a magnetic field. Yes or No. ( ) ————

25. It is *possible* to illustrate that a magnetic field surrounds a conductor carrying electric current. ( ) ————

26. If one starts with the loop in a vertical position in a magnetic field and turn the loop in a clockwise direction, the right side of the loop moves down through the magnetic field during the first half turn and sends a current through the conductor from the right side to the left side of the conductor. Yes or No. ( ) ————

27. During the second half turn the current is reversed. ( ) ————

28. Such a procedure is responsible for *continuous* current.   ( ) ———

29. A *split ring* is made by placing half of an iron ring on the ends of a wire loop carrying current from a magnetic field.   ( ) ———

30. A *drum armature* is essentially a cylindrical affair made by pressing sheets of thin iron discs on a shaft and winding loops of conductor lengthwise on the device.   ( ) ———

31. The iron core of an armature is much more *permeable* than the air which surrounds the armature.   ( ) ———

32. *Flux* in a magnetic field means the number of lines of force per unit area.   ( ) ———

33. *Permeability* means the resistance offered to the passage of magnetic flux in a circuit.   ( ) ———

34. Small motors are usually *bipolar* machines.   ( ) ———

35. In a four pole machine each wire loop cuts *a* complete set of magnetic lines during each revolution of the armature.   ( ) ———

36. Huge commercial motors are *multipolar* machines.   ( ) ———

37. In a *series* generator the field coils are wound with a few turns of large wire. When the current in the external circuit increases, the field is more highly magnetized and so a higher voltage is available.   ( ) ———

38. Electrical current can be supplied to a second type of machine and thereby used to drive machinery.   ( ) ———

39. Structurally a *motor* consists of an electromagnet, an armature and a commutator with its brushes.   ( ) ———

40. In starting large motors it is *necessary* to have large resistances in the circuit. As the motor gains speed, this resistance is reduced.   ( ) ———

41. In the motor the field due to the current in the conductor *acts in conjuction with the main field above the conductor and opposes the main field below the conductor.*   ( ) ———

42. The force acting on a conductor carrying a current in a magnetic field is *inversely* proportional to the strength of the field, the magnitude of the current and the length of the conductor lying in the field.   ( ) ———

43. In the *shunt* motor the field is connected directly across the line in parallel with the armature.   ( ) ———

44. When a load is applied to any motor, the *speed* of the motor is *not* affected.   ( ) ———

45. The *suitability* of a motor for any particular duty is determined by the variation of the torque and the variation of its speed with the load.   ( ) ———

46. If an ammeter and a lamp are connected in *series* with a small motor, and the armature of the motor held stationary when the current is applied, the lamp will glow brilliantly. When the motor is running the lamp will grow dim.   ( ) ———

47. A *starting resistance* is a set of coils of wire so arranged that the resistance may be adjusted

by moving a key from one coil to another. ( ) ————
48. On cranes and in electric automobiles shunt motors are used because this type of motor has a *large* torque. ( ) ————
49. The efficiency of a machine means the ratio of the *output* to the *input*. ( ) ————
50. The *frame* of a dynamo serves to make a part of the magnetic circuit and as a mechanical support for the machine as a whole. *Yes or No.* ( ) ————
51. The function of the brushes is to carry current from the *external circuit to the commutator.* ( ) ————
52. The force of the magnetic lines about the conductor and that of the magnetic field of the dynamo tend to turn or rotate the conductor in the magnetic field. Yes or No. ( ) ————
53. The torque of a dynamo depends on the flux and armature current. ( ) ————

CORRESPONDENTS FOR MR. LORENS CARLSSON, MALMO, SWEDEN.

Please refer to Mr. Carlsson's desire to correspond with American teachers, *Question No. 568*, SCHOOL SCIENCE AND MATHEMATICS, *January, 1931, page 92.*

The following respond: *Mr. A. C. Norris, McClure, Ill.; Mr. Mark P. Anderson, Watertown Junior High School, Watertown, Wisconsin.*

MID-YEAR EXAMINATIONS.

Examination papers in Biology, Chemistry, Commercial Science and Physics are acknowledged from *Wm. F. Rice, Head Science Dept., Jamaica Plain High School, Boston Public Schools.*

BOOKS RECEIVED.

Biological Foundations of Education by Otis W. Caldwell, Professor of Education and Director, Institute of School Experimentation, Teachers College, Columbia University, Charles Edward Skinner, Professor of Education, School of Education, New York University and J. Winfield Tietz, Instructor in the Departments of Biology and Health Education, DeWitt Clinton High School, New York City. Cloth. Pages vii+534. 13.5x21 cm. 1931. Ginn and Company, Number 15 Ashburton Place, Boston, Mass. Price $2.72.

The Carbon Compounds, A Textbook of Organic Chemistry by C. W. Porter, Professor of Chemistry in the University of California. Second Edition. Cloth. Pages ix+469. 15x23.5 cm. 1931. Ginn and Company, Number 15 Ashburton Place, Boston, Mass. Price $4.00.

Elements of Analytic Geometry by Clyde E. Love, Professor of Mathematics in the University of Michigan. Cloth. Pages xi+149. 13x20 cm. 1931. The Macmillan Company, 60 Fifth Avenue, New York. Price $1.60.

Plane Trigonometry with Tables by William Wilder Burton, Assistant Professor of Mathematics, Clemson College, Clemson College, S. C. Cloth. Pages x+125+vii+93. 14x21 cm. 1931. Thomas Y. Crowell Company, 393 Fourth Avenue, New York. Price $2.50.

Solid Geometry by Joseph P. McCormack, Head of the Department of Mathematics in the Theodore Roosevelt High School, New York City. Cloth. Pages ix+168. 12.5x19 cm. 1931. D. Appleton and Company, 35 West 32nd Street, New York. Price $1.24.

Mathematics for seventh, eighth and ninth year by Fred Engelhardt, Professor of Education in the University of Minnesota and
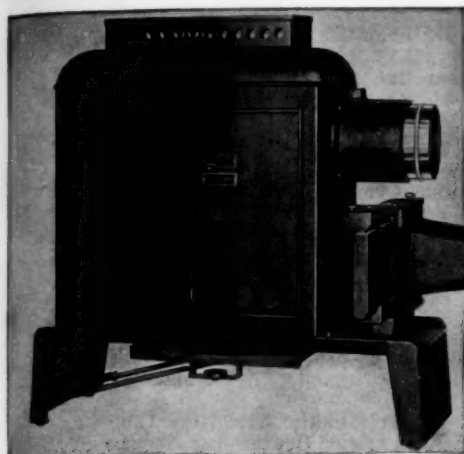
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MAKERS OF ORTHOGON EYEGLASS LENSES FOR BETTER VISION

Mary L. Edwards, Department of Mathematics Roosevelt Junior-Senior High School, Minneapolis. Cloth. 12.5x19 cm. Seventh year 248 pages, prize 96 cents; eighth year 285 pages, price 96 cents; ninth year 430 pages, price $1.24. 1931. D. Appleton and Company, 44 Hewes Street, Brooklyn, New York.

Geometric Concepts by Clara H. Mueller, Cass Technical High School, Detroit, Michigan. Cloth. Pages xi+205. 12x18 cm. 1931. John Wiley and Sons, Inc., 440 Fourth Avenue, New York. Price $1.60.

Mathematics for Junior High School Teachers, A Professional Subject Matter Text by William L. Schaaf, Department of Mathematics, Preparatory High School, College of the City of New York. Cloth. Pages xiii+439. 13x20.5 cm. 1931. Johnson Publishing Company, 8-10 South Fifth Street, Richmond, Virginia. Price $2.00.

PAMPHLETS.

Arithmetic Activities, Description of Arithmetic Activities Conducted at Gordon School formerly Curriculum Center for Arithmetic. R. G. Jones Superintendent of Schools and H. M. Buckley Assistant Superintendent of Schools. 213 pages. 13x18.5 cm. 1931. Published by Division of Publication, Cleveland Board of Education, Cleveland, Ohio.

A Graphic Method of Obtaining the Partial-Correlation Coefficients and the Partial-Regression Coefficients of Three or More Variables by Ernest Richard Wood, Director of Instructional Research, State Department of Education, Columbus, Ohio. Pages xi+72. 16.5x24 cm. 1931. The University of Chicago, Chicago, Illinois.

Report of the Survey Committee on Brown University. October, 1930, Vol. XXVII, No. 6. Published by the University, Providence, Rhode Island.

The Value of Law Observance, A Factual Monograph. Pages vi+57. 12.5x19.5 cm. 1930. Department of Justice, Bureau of Prohibition, A. W. W. Woodcock, Director, United States Government Printing Office, Washington, D. C.

Additions to the Flora of Connecticut, State Geological and Natural History Survey, Bulletin No. 48. Prepared by the committee of Connecticut Botanical Society consisting of Edgar Burton Harger, Charles Burr Graves, Edwin Hubert Eames, Charles Alfred Weatherby, Richard William Woodward and George Henry Bartlett. 94 pages. 14.5x23 cm. 1930. Connecticut State Library, Hartford, Connecticut.

Interferometers and Interference Apparatus. Catalog I. The Gaertner Scientific Corporation, 1201 Wrightwood Avenue, Chicago, Illinois. 48 pages. 19x27 cm. Description and price list of apparatus suitable for the college Light Laboratory.

Abstracts of Scientific and Technical Publications from the Massachusetts Institute of Technology including Abstracts of Doctors' Theses, July 1, 1930–December 31, 1930. Number 7, January 1931. The Technology Press, Cambridge, Mass.

Teachers' Catalog of Helpful Books, Supplementary Reading, Kindergarten Materials. 90 pages. 20.5x26 cm. 1931. Garden City Educational Company, 633 South Plymouth Ct., Chicago, Illinois.

Final Test in High School Physics, Forms A, B, and C also Manual of Directions by Professor A. W. Hurd, Institute of School Experimentation, Teachers College, Columbia University, New York. Forms A and B each have 82 questions and Form C has 83. 21x28 cm. 1930. Published by the Bureau of Publications, Teachers College, Columbia University, New York. Price $2.00 per one hundred.

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BOOK REVIEWS.

College Biology, by Henry R. Barrows, Associate Professor of Biology, New York University. xv+414 pp. 271 figures. Richard R Smith, Inc., New York, 1930.

The emphasis is placed on biological principles in this text rather than on plants and animals. This, of course, is as it should be. A notable feature of the work is its logical organization. Following the introductory Chapter I, chapters II, III, IV, and V are devoted to The Fundamental Structure of Plants and Animals. Chapters VI, VII, VIII, IX and X are concerned with the Nutritive Processes of Plants and Animals. Chapters XI, XII, and XIII deal with the Correlating Mechanisms. Chapters XIV to XVIII, inclusive, take up Reproductive Processes, Heredity, and Eugenics. The remaining chapters of the text, chapters XIX to XXIII, inclusive, are devoted to a discussion of the Theories, Evidences, and Results of Evolution. The appendix contains a list of biologists, a bibliography, and a glossary. Being so well organized, the text is particularly suited for use with classes in which the unitary method of instruction is used. The writer of this review considers this book a contribution strictly along the line of the modern trend in biology teaching.

Jerome Isenbarger.

Genetics, by Herbert Eugene Walter, Professor of Biology, Brown University. 380 pp. 91 figures. The Macmillan Company. Third edition. 1930.

The first edition of the book was published in 1913. This was revised in 1922. The present edition has resulted from an attempt to bring the subject matter up to date. Special attention is directed toward the theoretical and practical significance of the Mendelian laws in relation to the problems of production of better plants and animals. The last two chapters of the book deal with the application of the laws of genetics to man in the general problem of human conservation. There is nothing radically different in the subject matter of the text. The effective style and manner of presentation make the book useful not only as a text but also for reference and for general reading.   Jerome Isenbarger.

The Use of the Microscope, by John Belling, Cytologist, Carnegie Institution of Washington. 326 pp. 28 figures. McGraw Hill Book Co., 370 Seventh Ave., New York. 1930.

All of us who have used the microscope for many years have marveled as to possibilities for refinement of technique. This book brings together information gained through experience and experiments in the use of the instrument. Several dozen possible adjustments and variations of method for improving the sharpness and contrast of image are described in minute detail. Directions are given for the operation of the different types of microscopes with maximum efficiency. In addition to discussions covering the proper use of each part of the microscope, there are chapters on drawing, photography, microscopical objects, and practical exercises with the microscope. At the end of each chapter, there is listed a number of useful "practical points." At the end of the book, thirty pages are devoted to an extensive list of questions on the microscope and its proper use, a microscopical glossary, and a list of references. Instruction in the use of the microscope should receive more attention in biology classes than is usually given. The writer of this review knows of no other book suited to this purpose which covers the ground so thoroughly.   Jerome Isenbarger.

Presson Biology Test, by John M. Presson, Department of Biology, Girard College, Philadelphia. World Book Company, Yonkers-on-Hudson, New York. 1930.

The complete set consists of forms A and B of test 1 covering the

work of four and one-half months of plant biology, and test 2, forms A and B, covering four and one-half months of animal and human biology, together with manual of directions, keys, and class record blank. Forms A and B in either case are similar and of equal difficulty. Forms A and B of each test consists of three parts: Part I, 60 complete statements; Part II, 40 multiple-response questions; and Part III, 15 matching items. Judging from the manner in which the tests were constructed and validated, one would be compelled to consider them as nearly standardized for use in secondary schools in the United States as it is possible to make them. The nine falling statements of fact are given to call attention to a few inaccuracies. The anther of a flower does not produce the male cell. The flaky appearance of quarter-sawed oak is produced by medullary rays, but the grain is caused by annual rings. Seeds are attached to the pod by means of a funiculus. There are two regions of active growth in woody stems. Generally speaking, a fruit is more than a ripened ovary with its contents. The radicle develops into the root. The hypocotyl develops into a portion of the stem. Other substances than proteins are required to form the mixture known as protoplasm. Not only liquids and solids in solution but also gases in solution pass through membranes. The tests dealing with animal and human biology are excellent. There is much to be said in favor of the standardized test as an aid to the secondary school teacher, and others. Biology teachers will be interested in the Presson tests.

<div style="text-align: right;">Jerome Isenbarger.</div>

Laboratory Studies, Demonstrations, and Problems in Biology, by Nathan Harvey Kingsley, Late Director of the Department of Biology, Lincoln High School, Milwaukee, Wis. Arranged and Edited by Edward J. Menge, Director of the Department of Animal Biology, Marquette University, Milwaukee, Wis. The Bruce Publishing Company, Milwaukee, Wis. 1930.

The laboratory directions of this high school biology manual are divided into 95 assignments. There is also an Appendix A giving hints for collecting, and an Appendix B outlining a number of projects. There is much more work outlined than could be done by secondary school students in two semesters. This is a desirable feature, since it permits a selection of material to suit the particular needs of the class. The exercises can be selected in any desired order and exercises can be omitted if necssary. The work is that of an excellent teacher. The material is all usable, the directions are definite, and the main appeal is to the interests of the boys and girls in plants and animals as living things of the environment.

<div style="text-align: right;">Jerome Isenbarger.</div>

The Measurement of Man. Consisting of the Measurement of Man in the Mass, by J. Arthur Harris, Late Head of the Department of Botany, University of Minnesota; Normal and Abnormal Human Types, by Clarence M. Jackson, Head of the Department of Anatomy, University of Minnesota; Personality and Physique, by Donald G. Paterson, Professor of Psychology, University of Minnesota; and The Measurement of the Body in Childhood, by Richard E. Scammon, Professor of Anatomy, University of Minnesota. The University of Minnesota Press. 1930. $2.50. 222 pp.

This book should prove of interest to scientists in all fields and to intelligent laymen who are sufficiently patient to ponder the significance of an occasional mathematical formula or work out the meaning of graphical representation of fact. The four chapters of the book were delivered first as lectures under the auspices of Sigma Xi at the University of Minnesota. The different chapters call attention forcibly to the fact that "with all its apparent chaos, human structure and human function are after all subject to a system of orderly laws."

<div style="text-align: right;">Jerome Isenbarger.</div>

Plane and Spherical Trigonometry with Tables, by Leonard M. Passano, Associate Professor of Mathematics, Massachusetts Institute of Technology. Revised Edition. Pages xvii+155+xx+142. 12x19.5 cm. 1930. The Macmillan Company, 60 Fifth Avenue, New York. Price $2.10.

The text of this revised edition follows closely that of the original. In this edition, as in the original, we find the following features.

1. The trigonometric functions of the general angle are defined in terms of rectangular coordinates at the beginning of the book Thus, the fundamental trigonometric identities are derived in terms of this general angle.

2. The functions of the quadrantal angles are carefully explained by the theory of limits.

3. Three of the eleven chapters are devoted to spherical trigonometry.

4. There are numerous problems which are designed to illustrate the usefulness of trigonometry and to prepare the student for work in analytic geometry and calculus.   J. M. Kinney.

General Physics by Wm. S. Franklin, Professor of Physics in Rollins College and G. E. Grantham, Assistant Professor of Physics in Cornell University. Cloth. Pages xvi+705. 15x23 cm. 1930. Franklin and Charles, 510 Race Avenue, Lancaster, Pa. Price $4.00.

As we open this textbook of General Physics to the Table of Contents we find four parts: Part I Mechanics 170 pp., Part II Heat 111 pp., Part III Electricity and Magnetism 207 pp., Part IV Light and Sound 196 pp. Part I opens with a discussion of *forces* and passes along through *work and energy, motion, hydrostatics,* etc., and closes with a chapter on *elasticity.* This indicates that the authors have followed the general plan that has been approved for many years, and a comparison with a half-dozen other texts of this type shows little change in the relative emphasis. The indications thus far are that it is just another textbook; that it will neither produce a tide of enthusiasm nor will it offend many.

A more detailed examination reveals some variations. Part III does not start with magnetism and there is no chapter on static electricity. This section begins with a study of the effects of an electric current. Magnetism and the ideas of static charges are introduced as needed and many of the more elementary ideas of electricity are assumed to be a part of the student's general information. By this plan the authors are able to include more alternating current theory than is found in many other text. Part IV opens with a short chapter on the velocity of light and sound, followed by another very short chapter on wave motion. The discussion on light follows, leaving sound for the last large topic.

The book is decidedly technical in marked contrast to some of the other rather recent textbooks on this subject. The authors make free use of such units as the slug, abfarad, stat-coulomb, ster-radian, etc. Trigonometric solutions are common and the symbolism of differential calculus is used. The lists of questions and problems are exceptionally good. Modern theory is interwoven with classical physics. Twelve detached essays on topics related to physics are included. It is the reviewer's opinion that the book is not well suited to the needs of liberal arts, pre-medical and other such classes but teachers of classes of engineering students may well consider its adoption.   G. W. W.

Matter and Energy, An Introduction by Way of Chemistry and Physics to the Material Basis of Modern Civilization by Gerald Wendt, Formerly Dean and Oscar F. Smith, Assistant Dean, School of Chemistry and Physics, The Pennsylvania State College. First

Edition.   Volume I.   64 Illustrations.   Cloth.   Pages xiv+335.
13.5x19.5 cm.   1930.   P. Blakiston's Son and Company, Inc., 1012
Walnut Street, Philadelphia, Pa.   Price $1.50.

Matter and Energy, Vol. I, is a very interesting little volume, an
excellent book for the college freshman.   It is the authors' attempt
to produce a course that will give the fundamentals of science with-
out making such great demands on the students' time that many
are forced to abandon all attempts to acquire basic scientific knowl-
edge.   The book contains the material that is used in a combined
physics and chemistry course required of all Liberal Arts and Educa-
tion students in Pennsylvania State College.   No attempt is made
to differentiate between physics and chemistry.   The authors begin
the story with a discussion of questions which show the nature of
science, how scientific knowledge is acquired, and the fundamental
importance of physical science.   A lecture on the universe leads to
the study of measurement, the physical properties of matter, temper-
ature effects, transformations of matter, the gas laws, the kinetic
theory, wave motion, and to electrons and how our knowledge of
electrons and protons has accumulated.   With the facts thus set be-
fore the student, the basic scientific laws presented, and practice
given in following scientific thinking, the authors then give a mod-
ern view of the foundations of chemistry.

The entire book is a wonderful story told in a delightful way.
Students cannot but be interested and hence will be inspired to go
on, and to read much from the assigned and suggested reading lists
following each chapter.   No doubt many will acquire an abiding
interest in science.   Whether or not the course can adequately sup-
plant the usual courses in general physics and general chemistry
remains to be determined by measurement of the results.   It is,
however, the best attempt to combine the college courses in physics
and chemistry that has come to our attention, and merits the study
of curriculum makers.

Attention is directed to an error that has been frequently made
by others and is repeated on page 66.   The mass of the moon is
about *one-eightieth* the mass of the earth, not *one-eighth*.   In the
discussion of the effects of this difference in mass the authors have
failed to take into account the difference in density of the two bodies
and the fact that an object on the surface of the moon is only about
one-fourth as far from the moon's center of mass as an object on the
earth is from the earth's center of mass.   G. W. W.

The Stars Through Magic Casements Edited by Julia Williamson and
   Illustrated by Edna M. Reindel.   Cloth.   Pages xxi+239.   13x19
   cm.   1930.   D. Appleton and Company, 35 West 32nd Street, New
   York.

This is a collection of stories about the stars told in a fascinating
way for the entertainment of girls and boys.   But there is more than
mere pastime.   The myths and legends about the great star clusters,
the Milky Way and the brightest stars, gathered from the folk lore
of the American Indian, the ancient Romans, the Greeks and other
peoples teach many valuable lessons and enrich the lives of all who
read.   The stories are short and the style is conversational.   Poems
and pictures make the book more attractive.   It deserves a place in
the children's library.   G. W. W.

GOVERNMENT TO BUILD NEW RADIO LABORATORIES.

Two hundred acres of land near Washington will soon be pur-
chased by the Bureau of Standards of the U. S. Department of Com-
merce as a new site for radio research activities.   Experiments both
in sending and receiving will be made.   A number of buildings and
an experimental radio transmitting station will be constructed.

PROPOSED CONTENT OF A COURSE FOR THE TRAINING OF SCIENCE TEACHERS.

BY BRUCE W. MERWIN, SUPERVISOR OF STUDENT TEACHING,
Southern Illinois Normal University, Carbondale, Ill.

In the preface to his "Teaching Science in the Schools" Professor Downing has said:

> "Education is rapidly becoming a science. The problems of the selection of subject matter, its organization, and the methods of presentation which a generation ago were treated philosophically are now studied scientifically by patient observation, the accumulation of pertinent facts, experimentation, and inductive reasoning. The educator attacks the perplexities that confront him just as the chemist or biologist attacks the problem of making a more powerful explosive or creating a more productive breed of corn. There has already accumulated by this experimental method a rapidly growing mass of fact that bears on the problems of the pedagogy of science.
>
> "Strangely enough, the teachers of science have been among the last of the educational fraternity to carry the scientific method with which they are supposed to be saturated over into their problems of teaching. Many are still of the opinion that 'if one knows his subject he can teach it,' blissfully unaware that the science of education presents facts as certain and laws as sure as many in the subject he is teaching."

Since Professor Downing wrote the above, there has been considerable change in this matter. A study made by Mr. E. W. Phalen on the chemistry teachers of Ohio revealed that 185 out of 288 chemistry teachers had taken a course in "Methods of Teaching Science" or "Methods of Teaching Chemistry." This increasing emphasis on special method work for science teachers has been shown in a number of other studies.

A perusal of the catalogs of a number of universities and teachers' colleges shows that many such courses are listed, but also a wide lack of agreement in content. In many cases it appears safe to assume that the description of these courses was made by the head of the department rather than by the instructor actually offering the course.

In order to learn what the content of such courses might be, a list was made of phases of the work stressed by the various books on science method and in the more recent issues of "School Science and Mathematics" and the "Journal of Chemical Education." From this a list of forty-two items was secured. The list of items was submitted to twenty-five teachers of special science method in the leading state universities, colleges, and teachers' colleges in the Middle-West, who considered them in terms of their con-

tribution to a course in teaching high school science and evaluated them as "essential, desirable, unnecessary, or undesirable."

The tabulation of these entries is shown in the following table. This tabulation does not quite accurately represent the general conditions on account of certain variations in prerequisites. In some schools educational courses and certain courses in the subject to be taught are assumed as prerequisites and, accordingly in some cases, important items are not considered essential in a course of special method. For instance, *"Repair and Care of Apparatus"* in the University of Chicago is taught in the subject-matter courses in the science department and items such as *"Types of Teaching, Laws of Learning, Transfer of Training,"* are taught in the general methods course, which is prerequisite. Hence these were not considered necessary in a course in special method.

The first four items are those which are almost universally accepted as essential to such a course. The high rank of the fifth item on the use of projection apparatus is of interest because it indicates that there is an increase in recognition of the practical character of visual education; and that while as yet but little actual use is being made of visual education in high school teaching, those who will prepare teachers recognize and stress the value of such innovations as the movie and the talkie.

The *"Evaluation of Texts"* is also recognized as an important item, perhaps because during the past few years a large number of science texts have flooded the market. The instructors of high school science method courses have found it almost essential to present standards for evaluating texts so that the beginning teacher may not select poorly organized, out-of-date, or otherwise inferior texts.

The early appearance of the item *"Aim and Function of the Laboratory,"* considered essential by seven-ninths of those offering opinions, is thought to be due to the lack of adequate ideas as to the purpose of the laboratory on the part of teachers in actual service.

Since the remainder of the items were tabulated according to their importance it is hardly necessary to comment on them.

It has been the purpose of this study to furnish those who are training science teachers an evaluated list of suggestive items which might be considered in the development of such a course. It has not been the purpose to suggest a scheme of organization or the amount of emphasis to be given the various items, as it is very evident that preliminary work and requirements vary greatly in different institutions as do also the conditions under which science method courses are offered.

CONTENT OF A COURSE IN METHOD OF TEACHING HIGH SCHOOL SCIENCE
Ranked according to importance

Rank   Items
1   Selection of Subject Matter
2   Aim, Function or Values of Subject
3   Selection and Purchase of Equipment
4   Preparation of Efficient Demonstrations
5   Use of Projecting Apparatus, Including Movie and Talkie
6   Repair and Care of Apparatus
7   Evaluation of Texts
8   Aim or Function of Laboratory
9   Student's Use of Note Books, Drawings, Graphs
10   Laboratory Technic
11   Selection and Purchase of Supplies
12   Lesson Plans
13   How to Study
14   Use of Libraries, Bibliographies, Current Literature
15   Relation of Subject to Other Subjects in Curriculum
16   Standards of Good Class Work
17   Observation of Actual Teaching
18   Motivation and Interest
19   Technic of Review
20   First Aid in Laboratory
21   Laboratory Rules
22   Use of Excursions
23   Making Cultures, Solutions, etc.
24   Spectacular Demonstrations
25   Technic of Questioning
26   Use of Objective Tests
27   Use of Standard Tests
28   Concept Building
29   Ability of High School Students to Think and Respond
30   Free Literature on Subject, Government and Manufacturer
31   Free Demonstration Materials (including Visual Aids)
32   Organization of Science Clubs
33   Types of Teaching
34   Teacher's Use of Syllabi
35   Fallacies of Science
36   Dewey's Act of A Complete Thought
37   Supervised Study
38   Posters
39   Oddities of the Subject
40   Laws of Learning
41   Herbart's Five Formal Steps
42   Transfer of Training

AN EXPERIMENT ON THE THEORY OF MAGNETISM.

By Joseph A. McGee,

Seymour High School, Seymour, Conn.

I wish to suggest for the benefit of general science teachers and physics teachers who, like me, are trying to arrange laboratory experiments that are simple, inexpensive and yet effective, a method of showing the theoretical structure of a magnet.

Cover the bottom of a small beaker or drinking tumbler with iron filings. Place the beaker between the poles of as strong a horse shoe magnet as is available. The magnet from the magneto of an old Ford works well. Shake the beaker in a direction parallel to the poles of the magnet, or tap it gently on the table between the poles of the magnet. The iron filings can be seen by any observer to be lined up in a regular manner.

If the beaker containing the iron filings is now brought near a magnetized needle without disturbing their arrangement, each end of the iron filing magnet will repel opposite ends of the magnetic needle.

If a shallow dish is used rather than the beaker and after magnetizing the filings in the dish, it is covered by a piece of stiff paper, iron filings sprinkled on the paper show a magnetic field about the iron filing magnet.

To show how a magnet is demagnetized shake the beaker to disarrange the iron filings. When disarranged they show no magnetism.

Any one can clearly see from this experiment that the arrangement of the constituent parts of the magnet is very significant.

NEW VEGETABLES STUDIED BY GOVERNMENT EXPERTS.

Educating the public to the food value of the host of new vegetables continually being discovered by plant explorers and brought from all over the world to enrich the American diet, the Bureau of Home Economics of the U. S. Department of Agriculture has published a report on the chemical composition and nutritive value of the dietary newcomers and some new facts about old vegetable standbys.

Chinese cabbage, broccoli, dasheens and a score of other vegetables were almost unknown in this country a few years ago but are common today. To determine the nutritive value of these stranger foods, typical samples were taken and analyzed.

Buying a pound of Chinese cabbage, for instance, the housewife is getting food with a fuel value of approximately 75 calories. An average sample of this vegetable is approximately 95 per cent water. The rest of its bulk is made up of nitrogen, 1.4 per cent; fat, .1 per cent; ash, .89 per cent; fiber, .6 per cent; sugar, .9 per cent; starch, .2 per cent. Outer leaves and core of Chinese cabbage, amounting to 13 per cent of the vegetable, are waste.

Similar reports for the other new vegetables reveal the chemical content and food value of these diet innovations. The study was conducted by Charlotte Chatfield and Georgian Adams of the Bureau of Home Economics.—*Science Servivce.*

A LOCOMOTIVE FOR THE PHYSICS CLASS.

BY ROY R. HATCH,

Mount Hermon School, Mount Hermon, Mass.

[This very interesting experiment shows how an alert teacher can illustrate the use of the most prosaic laws of physics in a great industry. No toy apparatus in this. It makes education a picnic.—Ed.]

OBJECT OF EXPERIMENT:

(1) To determine the acceleration of a B. and M. R. R. passenger train leaving Mount Hermon Station.

(2) From the acceleration obtained in (1) to determine the tractive effort to overcome the inertia of the train.

(3) With surveyors' instruments measure the grade of the track and calculate the tractive effort required to lift the train up the grade.

(4) Assuming the coefficient of rolling friction for a railway carriage calculate the tractive effort to overcome friction.

(5) From above data calculate the H. P. of the locomotive, developed at the rails, when train is moving at maximum speed obtained.

DATA:

Weight of locomotive and train 743,000 lbs.

Grade of track .476 feet in 100.

Assume coefficient of rolling friction as .004.

Space taken 3000 ft.

Time for train, from state of rest, to cover this distance, 105 seconds.

$$\text{Average Vel.} = \frac{\text{space}}{\text{time}} = \frac{3000}{105} = 28.57 \text{ ft. per sec.}$$

Final Velocity $= 28.57 \times 2 = 57.14$ ft. per sec.

$$\text{Acceleration} = \frac{57.14}{105} = .544 \text{ ft. per sec. per sec.}$$

$$\text{Force or Tractive Effort} = \frac{\text{Mass} \times \text{Acceleration}}{32}$$

$$= \frac{743000 \times .544}{32} = 12631 \text{ lbs.}$$

$$\text{Tractive effort to overcome grade} = \frac{743000 \times .476}{100} = 3536 \text{ lbs.}$$

Tractive effort to overcome friction $= 743000 \times .004 = 2972$ lbs.

Total Tractive effort $= 19139$ lbs.

H. P. Developed at velocity of 57.14 ft. per sec.

$$= \frac{19139 \times 57.14}{550} = 1988 \text{ H. P.}$$

I find that after my pupils have had this work on work, power, force, acceleration, inclined planes and general laws of machines that this problem is fine for review work and they enter into it with a good deal of zest. We are about one mile from the railroad station and on a Monday, our holiday, I take the boys over and they get a lot of fun out of the project of measuring the grade, obtaining the velocity and acceleration of the train and "chumming" with the engineer and fireman.

NEWSPAPER BAKED TO TEST PERMANENCE.

If a piece of newsprint paper can pass the test of being baked for 72 hours at the boiling point of water, it is suitable for printing permanent library editions.

This test was devised by the Bureau of Standards of the U. S. Department of Commerce at the request of newspaper publishers. The results indicated that papers today can be printed to last if special paper, containing a minimum of impurities, is used.

After being subjected to the severe heat test, the recommended papers showed little loss in folding strength and their chemical composition was practically unchanged by the baking.—*Science Service.*

"GRAND-SCION" OF WASHINGTON ELM TO REPLACE FALLEN ANCESTOR.

A tree that is a true Son of the American Revolution stands on the campus of the University of Washington, ready to "go back East" whence its parent came, to take the place of a famous ancestor, now dead.

It is the offspring of the great Washington elm of Cambridge, Mass., under which General Washington stood when he assumed command of the Revolutionary army, then besieging the British in Boston. This great tree stood as a living patriotic monument until at last old age and disease overcame it in 1923.

But before the old elm died it had left offspring. In the current issue of American Forests, Heister Dean Guie tells the story of one of its lines of descent.

Thirty years ago, Arthur J. Collins, a graduate of the University of Washington, was studying at Harvard. Seeing that the Washington elm could not live much longer, he obtained the consent of the city officials of Cambridge to have cuttings made for later transplantation to the campus of his Pacific Coast alma mater.

Two of these scions, set out in the same hole thirty years ago, are now the pride of the University of Washington campus, and top the four-story building in front of which their twin trunks rise.

To obtain the "grand-scions" for re-planting in place of the original Washington elm, boxes filled with earth and moss were clamped around two of the best limbs. The mass of soil induced the sprouting of roots. The limbs could then be sawed off and planted in the ground as independent trees. They now await word from Cambridge, when they will be shipped back to the city where their grandsire achieved immortality in the stirring days of 1775.—*Science Service.*